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Science and Mathematics Education Centre

A COMPUTER-ASSISTED SCIENTIFIC LITERACY DEVELOPMENT PLAN FOR SENIOR SECONDARY STUDENTS

by
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ABSTRACT

This study provides a definition of scientific literacy applicable to secondary school science students. The definition was developed from theories about cognitive processes, the discourse of science, the language register of science and cognitive writing processes. A computer-assisted Scientific Literacy Development Plan was formulated and classroom research undertaken to test its effectiveness. A model of cognitive writing was used as an application of the Scientific Literacy Development Plan in classroom research. The model is called a HyperCard Pathways writing model.

The research methodology was a combination of qualitative and quantitative methods and took place in three phases over three academic school years. The HyperCard Pathways model of writing was developed in modules for the topics of the Year 11 Physics Extended Subject Framework of the Senior Secondary Assessment Board of South Australia. Students used the modules for the completion of required pieces of writing in science as part of the requirements for the South Australian Certificate of Education. Results indicated that the Scientific Literacy Development Plan was an effective tool for the enhancement of scientific literacy of Year 11 physics students and there was potential for use of the plan in other science subjects. A number of teachers incorporated the techniques of the Scientific Literacy Development Plan into their regular course schedules.

In conjunction with the classroom research, a method to assess explanation genre essays was developed called the Scientific Explanation Genre Assessment Scheme. This was trialled independently of the trials of the Scientific Literacy Development Plan and was found to be used reliably by teachers of Year 11 physics. The effectiveness of the computer-assisted Scientific Literacy Development Plan was demonstrated by evidence of improvement in scientific writing beyond that of normal practice. The products of this research: lesson plans, computer discs, and supporting materials were developed to be of assistance to other teachers. The materials can be adapted to other modules in the science curricula, and, following this project some teachers have chosen to do this.

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GLOSSARY

Acronyms

CASSR	Concepts, Attitudes, Aspects, Strategies, Range: A framework for literacy assessment
DEET	Department of Education, Employment and Training
ESL	English as a Second Language
HCP	HyperCard Pathways modules
ILY	International Literacy Year
MANOVA	Multivariate Analysis of Variance
NAP	New Arrivals Program
NESB	Non-English Speaking Background
SACE	South Australian Certificate of Education
SEGAS	Scientific Explanation Genre Assessment Scheme
SLDP	Scientific Literacy Development Plan
SOLO	Structure of Observed Learning Outcomes
SSABSA	Senior Secondary Assessment Board of South Australia
TORCH	Tests of Reading Comprehension
WBLA	Writing Based Literacy Assessment
WISP	Writing in Science Potential
WRAP	Writing and Reading Assessment Program

Computer Terminology

Apple™	Name of a hardware and software company
appletalk	A system of linking computers in a network
bold	A font style for emphasis
button	A screen icon to direct the next movement
card	The single units within a stack
click	The operation of the mouse button
chunking	The grouping of a certain amount of text
cut	To remove a section of text or graphics
daisy chain	A system of linking computers in a network
data show	Instrument linked to a computer and overhead projector

default	The automatic setting
digicard	Type of software for interconnection of machines
disc	The magnetic disc on which the program is stored
disc density	The capacity of a disc for storage of information
disable	To adapt a menu
edit	The list of commands to change text
erase	To remove a section of text or graphic
ethernet	A system of linking computers in a network
field	The section of screen in which text can be written
file	The file menu is the list of the software commands.
font	Size and style of the print
Grammatik	A program for grammar checking
HyperCard	Software to enable users to write application programs
line tool	A tool in hyperCard to draw lines
lock	The script program is locked by a software command
Macintosh	Name of a series of machines made by Apple Company
machine	The type of computer machine such as Mac Plus, LC, SE/30
menu	A list of actions that can be chosen.
menu bar	The menu headings at the top of the screen
microsoft word	Name of a word processing software package
menu item	One of the actions under the menu that can be chosen
mouse	Hand device that controls the pointer on the screen
new	The command to create a new stack, card, fields, button.
network	The group of interconnected machines
options	A number of graphics available such as paint, patterns
paste	A command to insert copied text or graphic
pathways	A pattern Of interlinked buttons, fields, cards, stacks
pop-up	A widow remaining visible while the mouse button is held
pull-down	A command to make a menu visible for selection of items
read-only	part of the document that can be read but not written to
resize	A command to enlarge or decrease visible window
scan	Copying text or graphics directly onto a computer script
script	The list of typed commands
screen	The visible window of the video monitor

scroll	To move around a document outside the visible screen
software	The computer programe
stack	A collection of cards which contain units of information
style	The appearance of the text
tool	A menuitem that allows choice of types of graphics
unlock	To remove the restriction within a read-only text
userlevel	The level of use or changes that can be made
word	A software package for word processing
works	A software package for word processing and other skills
write to	A command to enable a disc to receive informatioon

Other Specific Terminology

bands	Refers to the categories of WISP
components	Refers to the individual strategies of SLDP
elements	The sections of the definition of scientific literacy
features	Refers to the characteristics of concept mapping
HCP model	The proposed HyperCard Pathways model for scientific writing
HCP modules	The computer programes for each topic
hypertext	Refers to the non-linear synthesis of information
pathways	Refers to the various routes taken in a hypertext document
project	Refers to the whole study of SLDP
schedule	Refers to a teacher's course outline
study	Refers to the pilot study, first or second extended study
trial	Refers to the experimental a period of time

Use of Italics
for

- *Computer terminology*
- *Student and teacher quotations*

CHAPTER 1
INTRODUCTION

This thesis reports a study into the meaning of scientific literacy and the construction of a Scientific Literacy Development Plan (SLDP) for upper secondary science students. The study provides teachers with a strategy for enhancing the scientific literacy of students within the framework of regular science course schedules. To introduce the study, a description is given in this chapter of the background and need for the study. The purpose of the study is then described, leading to the formal research questions and the research design, followed by discussion of the significance, scope and limitations of the study. An overview of the following chapters is provided at the conclusion of this chapter.

Background and Need for the Study

The Background to the Research

The researcher, a practising physics teacher, was influenced in the first instance by the questions raised about literacy by the Enquiry into Immediate Post-Compulsory Education in South Australia (Gilding, 1989). About the same time, in 1988, a Writing and Reading Assessment Program (WRAP, 1990) was being conducted in primary and junior secondary classes in all curricula including science, by a joint project team from the Education Department of South Australia, the South Australian Catholic Education Office and the South Australian Independent School Board, representing over 95% of all students in the State. Many of the questions raised were similar to those that subsequently received international focus at a more general level during the United Nations' International Literacy Year (ILY) in 1990. The discussion here begins with the more general issues raised by the ILY in the context of scientific literacy, before describing the specific concerns raised in the two South Australian projects.

Concerns in the International Literacy Year

The year 1990 was declared the United Nations' International Literacy Year (ILY). Surveys were conducted into the state of literacy around the world and many developmental projects were initiated. The general aim of the researchers and developers was to improve the literacy skills of people in areas of need, not only in third world countries but in Australia as well. With an estimated one million Australian adults with literacy problems (Department of Employment, Education and Training, 1990), the social cost of inadequate literacy had a multi-hundred-million dollar price tag in the annual budgets, 1990 to 1994, for implementation of The Language of Australia, the literacy and language policy (Department of Employment, Education and Training, 1990). The definition of adequate literacy accepted by the Australian Government was in accordance with the definition adopted by the National Consultative Council for International Literacy Year:

> Literacy involves the integration of listening, speaking, reading, writing and critical thinking; it incorporates numeracy. It includes the cultural knowledge which enables a speaker, writer or reader to recognise and use language appropriate to different situations. For an advanced technological society such as Australia, the goal is an active literacy which allows people to use language to enhance their capacity to think, create and question, which helps them to participate effectively in society. (Hartley, 1989, p. 4)

The Australian Language and Literacy Policy (Department of Employment, Education and Training, 1990) drew attention to the social dimensions of literacy. Hartley (1989) of the Department for Employment, Education and Training, analysed the social costs of inadequate literacy in the Australian context and found significant impact in the areas of family life, health, consumer rights, employment, occupational health, crime and social welfare. Hartley claimed that a causal relationship existed between inadequate literacy and social cost. In this context the notion of an 'active' literacy was described in terms of life-cycle phases by Levine (1986), who argued that literacy had a different relevance for people at various stages of their lives. This need for active literacy in the work-place, home and society was clearly demonstrated by the results of attitudinal surveys concerning the future reported by Eckersley (1988a). Eckersley (1988b)drew a connection between attitudes to science and technology and the predicament in which the young would find themselves if they were not literate in science and technology.

In a review about Australian attitudes to future science and technology, Eckersley (1987) reported a pervading pessimism shown particularly in the anxiety of the young. Very few felt they were well enough informed about science and technology for adequate utilisation. According to surveys (Eckersley, 1987), the casualties of rapid change in an increasingly scientific and technological society would be the young. Eckersley concluded that concerns about scientific and technological progress appeared to be a major factor beneath the pessimism of young Australians towards the future. Therefore it seemed that the need to find a strategy for enhancing scientific literacy in secondary school students was appropriate to this research and was fulfilling part of ILY concerns.

The Educational Response

As a consequence of the impetus of ILY concerns, the Australian Government funded a number of projects aimed at the improvement of the teaching of literacy in schools. The four macro skills of reading, writing, listening and writing were addressed in various projects. A synopsis of thirty one such projects was published by the Department of Employment, Education and Training (1990) for the professional development of teachers in the Government and non-Government sectors of secondary education in Australia. The thrust of many of these projects was for literacy in the context of language skills across the curricula, including science curricula. However, there were no specific projects for scientific literacy in the context of scientific knowledge or the communication of that as an expression of social concern. Also, a perusal of an annotated bibliography (Lendon & Schodde, 1989) of 151 science education publications in the areas of current policy statements, curriculum materials and classroom ideas, indicated that only one project was dedicated to scientific literacy and that was in the context of assistance for English as a Second Language (ESL) students (Commonwealth Schools Commission, 1986).

Two major initiatives for enhancing general literacy in South Australia were in progress before ILY and continued during that year and beyond. They were the Enquiry into Immediate Post-Compulsory Education (Gilding Enquiry) and the Writing and Reading Assessment Program (WRAP). The Gilding Enquiry led to major changes in curriculum, assessment and reporting practices in the final two years of secondary school, while WRAP was an assessment of the reading and writing practices across the range of Year 6 to Year 10. The findings are discussed in the following paragraphs, and these, together with the general inadequacy of specific scientific literacy projects Australia wide, suggested the idea of a Scientific Literacy Development Plan (SLDP) for development in this project.

The Need for a Scientific Literacy Development Plan

The need for a Scientific Literacy Development Plan (SLDP) in the upper secondary science classes became apparent from a study of the findings from four sources: the Gilding Enquiry into the Immediate Post-Compulsory Education, the Writing and Reading Assessment Program (WRAP), some specific results of extended writing questions in the Public Examinations in Science over a period of five years from 1986 to 1991, and the language needs of non-English speaking background (NESB) students in upper secondary science. These four sources are described in the following paragraphs.

Enquiry into Immediate Post-Compulsory Education

The Gilding Enquiry was conducted by Professor Kevin Gilding from January 1987 to October 1989. After examination of submissions from all sectors of education, commercial and industrial sectors, two reports were prepared and submitted to the Minister for Education (Gilding 1988, 1989). The central proposal of the first report was for a reorganisation of the final two-year curriculum with emphasis placed on literacy, work preparation, Australian cultural studies, and articulation to post-secondary education. The first report (Gilding, 1988) resulted in large scale changes to the management of the final two years of secondary education in curricula, assessment and reporting practices, and articulated pathways to further education. It recommended the introduction of a new South Australian Certificate of Education (SACE) for students completing four semesters of upper secondary education. The recommendations were subsequently accepted by the Government.

The second report (Gilding, 1989) recommended that the new certification process should include a compulsory literacy assessment across a range of subjects, called the Writing Based Literacy Assessment (WBLA) folio (Senior Secondary Assessment Board of South Australia, 1990), which was to include at least one piece of writing from the science, technology or mathematics subjects in the first two semesters, normally Year 11 for most students. There was also to be a requirement for a certain number of 'language rich' subjects in the third and fourth semesters, normally Year 12 for most students. Science subjects in each of the semesters were to include scientific literacy objectives in each school's statement of course objectives. Clearly there was to be an emphasis on development and assessment of literacy skills across all subjects in order to qualify for the SACE.

The challenge for students in the science subjects was to produce four pieces of extended writing for teachers to assess according to literacy criteria. These criteria were principally coherence, that is making sense as a whole to a reader, and fluency, that is the logical flow of ideas. In planning for each semester, objectives in scientific literacy were required to be met in all science subjects. In addition two of the four science subjects, physics and biology, were to continue with the inclusion of an essay question worth 16% and 20% of the marks respectively in the public examinations. These changes resulted in teachers looking for strategies to enhance the scientific literacy of their students thus supporting the need for studies such as that reported in this thesis.

The Writing and Reading Assessment Program

The Writing and Reading Assessment Project (WRAP) was a three year research project conducted from 1989 to 1992. The enquiry focussed on the literacy skills of Year 6 and Year 10 students. Groups of classroom teachers were involved in workshop sessions for training in group assessment to establish consistency in the marking of writing tasks to be used in the project. The first stage in WRAP involved finding out what opportunities students were receiving in their classrooms to become effective readers and writers. The monitoring of writing involved the collection of all writing done by students over a four week period in all subjects across the curriculum at the Year 6 and Year 10 levels in a random sample of 61 schools (32 primary and 29 secondary) in South Australia. Sampling was done during the collection period and the extensive guidelines which were given to participating teachers are described in the WRAP Final Report (Education Department of South Australia, 1992).

The literacy tasks included a variety of forms of writing such as narrative, autobiographical writing, science report writing, persuasive writing, summaries, fiction reading responses and non-fiction research reports. Students also did reflective writing about themselves as writers, which was used to assess the relationship between attitude and performance. The project team and the participating teachers examined the samples of writing and the teachers' contextual information in order to categorise the writing into a number predetermined aspects of literacy in writing. The categories were form, complexity, authorship, student choice, presentation of the writing. The analysis of writing in WRAP indicated differences between subjects in the different writing tasks that students performed. The interest here was in the data concerning writing in science which were significantly different from that of other subjects in a number aspects of writing as shown in Table 1.1. The Interim WRAP Report (Education Department of South Australia, 1990) indicated that Year 10 students had significantly under-performed in scientific writing tasks compared with writing tasks in other subjects. Results of tests in reading assignments in science, also indicated under-performance compared with that of other subjects.

Table 1.1 compares aspects of writing in science with aspects of writing in all subjects and is derived from the WRAP Final Report (Education Department of South Australia, 1992). A random sample from a representative sample of 3,663 Year 10 students across the state, meant that between 200 to 228 students supplied pieces of writing for each of five writing tasks within the two week collection period. The writing pieces were then categorised by the project team using contextual information supplied by the sample teachers.

Table 1.1

The Frequency of Writing in Science Compared with Other Subjects

Categories	Aspects	All Subjects (%)	Science (%)
Form	originals	29.2	22.5
	transfers	31.1	8.3
	set exercises	35.8	38.3
	reproductions	21.7	30.3
Complexity	single word	13.0	11.0
	phrase	16.6	17.4
	separate sentences	37.0	49.4
	connected sentences	19.6	16.9
	extended prose	13.0	4.4
Authorship	own words	45.7	40.6
	copied	22.2	27.4
	combination	28.4	31.0
	translations	2.8	0.2
Choice	some	23.4	8.4
	none	75.7	88.8
Purpose	show knowledge	58.4	72.8
	skill practice	12.2	2.4
	other	30.1	24.6
Presentation	illustrations	21.5	50.8
	print only	78.0	47.7

The frequencies of original and transformation forms of writing in science were considerably lower than in other subjects while higher for set exercises and reproductions. The written answers in science were higher in single word answers, phrases and separate sentences than in other subjects and correspondingly lower in extended prose. The aspects of authorship indicated a lower use of students' own words and a higher use of copied material in science compared with other subjects. Student choice allowed in writing tasks was less in science than in all other subjects. The purpose of science writing was largely to demonstrate knowledge rather than to practise writing skills. The presentation of written work was markedly different in science because of the use of diagrams, graphs, and illustrations.

The areas of weakness in scientific writing were therefore identified as little variety of form, low level complexity, deficient personal authorship and narrow purpose of the writing. There was a clear need for development in these areas in the post-Year 10 science students, particularly in the light of the requirements for WBLA and SACE (from the Gilding Enquiry) that were due to be implemented in 1992.

In the further analysis of results of those students from low socio-economic backgrounds identified from school card entitlements (Government financial assistance), there appeared to be no difference from other students in scientific writing although there were differences in other writing tasks. In the gender analysis there was a difference in favour of girls in the aspects of language complexity and conventions in scientific writing performance but no differences in regard to the production of ideas or the organisation of the science task. In the analysis of non-English speaking background (NESB) there was a negative difference in the aspects of language complexity and conventions in scientific writing performance but no differences in regard to the production of ideas or the organisation of the science task.

The analysis into reading within the Year 10 sample (210 students) indicated that students enjoyed considerable choice in what they read for school and recreation, in contrast to the low level of choice in writing. A high 80.5% of students reported that they liked reading. Students showed a clear preference for reading fiction (50.9%) compared with non-fiction (13.0%) and with no preference (36.0%). The gender difference in preference for non-fiction was significant, being 20.4% for boys and 6.2% for girls. The WRAP report suggested that teachers and teacher-librarians needed to be more energetic in promoting interesting biographies, auto-biographies, true stories and nature stories as recreational material. There was no mention of scientific reading. The kinds of preferred reading material in rank order were: entertainment magazines, novels, comics, computer magazines, newspapers.

The WRAP Final Report (1992) indicated that the issues for crucial consideration were the range of literacy tasks assigned to students, the genres introduced to students, the curriculum processes and content, and assessment procedures for more effective literacy outcomes (Education Department of South Australia, 1992). The WRAP project reported on the needs of minority groups and educationally disadvantaged in relation to the literacy tasks. These issues were considered in the development of SLDP as described later.

Examination Results of Extended Writing Questions

The results of students' writing performance in science in the Public examinations of the four science subjects: physics, chemistry, biology, geology, indicated some interesting differences. While all four examinations contained questions requiring explanation type answers, only physics and biology included substantial marks for extended writing in the form of a essay questions. The results of these essay sections in physics and biology indicated differences between these subjects in writing performance. Over the years 1986 to 1991 there were significant differences between physics and biology in the proportion of marks gained for the essay section of the paper compared with marks gained for the non-essay sections of the paper.

Physics. In the essay section carries 16 marks while the non-essay sections carried 84 marks. The mean scores of the essay section are compared with the mean scores of the non-essay sections in Table 1.2, and converted to a percentage of the total possible marks for each of these sections for comparison. Paired t-tests indicate significant differences ($p < .001$) for five of the six years, suggesting that approximately 11% (or two marks in sixteen) for the essay question were lost due to the inability to communicate the level of physics knowledge already demonstrated in the other sections of the examination paper. The number of students who did not even attempt the essay, even though compulsory, varied from 3% (90 students) to 9.4% (284 students). This was a further indication that physics students had difficulty with writing in physics.

Table 1.2

Comparison Of Means: Essay versus Non-Essay Marks In Physics

Year	Mean of essay question (% of 16)	Mean of non-essay questions (% of 84)	Difference (%)
1991	6.37 (39.81)	44.88 (53.44)	13.63*
1990	6.64 (41.50)	39.66 (47.21)	5.71
1989	5.99 (37.44)	40.15 (47.80)	10.36*
1988	5.92 (37.00)	47.14 (56.13)	19.13*
1987	7.20 (45.00)	47.69 (56.77)	11.71*
1986	6.36 (39.75)	43.05 (51.26)	11.51*

* p < .001

Biology. The comparison of marks gained in the essay section in biology with the marks gained in non-essay sections is depicted in Table 1.3. The essay carried 20 marks from 1986 to 1990 and 15 marks in 1991. The biology results are in contrast to the physics results, and paired t-tests indicate no significant difference ($p < .001$) in five of the six years between the marks in the essay question and the marks in non-essay questions. The number of students not attempting the essay question was also less than was the case in physics, varying between 1.4% (70 students) and 4.7% (235 students).

Table 1.3

Comparison Of Means: Essay versus Non-Essay Marks In Biology

Year	Mean of essay question (% of 20, 15)	Mean of non-essay questions (% of 80, 85)	Difference (%)
1991	8.14 (54.27)	46.89 (55.16)	0.89
1990	9.23 (46.15)	44.96 (56.20)	10.05*
1989	11.95 (59.75)	50.32 (62.90)	2.45
1988	10.32 (51.60)	46.48 (58.10)	6.50
1987	9.59 (47.95)	43.36 (54.20)	6.25
1986	11.12 (55.60)	43.66 (54.58)	1.02

* p < .001

Analysis of difference. An analysis of the reason for the different patterns in performance for physics and biology was reported by Whitehouse and Sullivan (1992). In biology the questions were highly structured and the content was quite specifically required. Whitehouse and Sullivan (1992) reported for biology that:

> Students score more highly if they move straight into answering the question, closely following the clues suggested by the wording of the question. It is clear that biology essays are not 'essays' as the term would apply to an English syllabus. In this respect, biology essays may in fact bear more resemblance to longer extended response questions, with style having a peripheral value. (p. 44)

In biology, the questions were ones in which students were asked primarily to recall learned content or procedures. The instruction words included 'state', 'which', 'name', 'list', what', 'describe' and similar phrases. The examiners advised that content mark would be 16 out of 20. The requirements for clear, logical and precision in responses were awarded a 'style mark' of 4 marks in 20 marks. The questions generally required factual recall and demonstration of factual learning of syllabus content to the examiner. An example of such a question is as follows:

> Glucose plays an important role in the metabolism of all organisms, both as a source of energy and as a raw material. Discuss this statement by referring to:
>
> (a) at least two of the structures (organelles, cells, tissues, organs) in autotrophs which contribute to the manufacture of glucose and its distribution around the organism;
>
> (b) at least two of the structures (organelles, cells, tissues, organs) in heterotrophs which contribute to the manufacture of glucose and its distribution around the organism;
>
> (c) the common processes in autotrophs and heterotrophs in which glucose is used as a source of energy and as a raw material. (SSABSA, 1989a, p. 27)

The physics essay questions were set more in the form of an explanation genre with instruction words such as 'explain', 'give a reason', 'why', 'discuss', 'give an explanation for' and other similar phrases. The essay questions were designed to make demands on the students' reasoning skills and to show an understanding of scientific relationships (Whitehouse & Sullivan, 1992). An example of such a question is as follows:

> Theories suggest that there is an underlying order and beauty in nature. An experimental discovery can confirm, extend, or contradict a prevailing theory. Discuss the 'Contribution of Theory and Experiment to Physics' in an essay, with particular reference to the double-slit experiment in optics and to the photoelectric effect. (SSABSA, 1989b, p. 4)

In contrast to biology, the physics examiners were more intent on the logical explanation of ideas with appropriate content to support the explanation rather than the amassing of facts linked coherently. This difference in emphasis was the reason attributed by Whitehouse and Sullivan (1992) to the difference in scores between physics and biology essays. Whitehouse and Sullivan were more interested in the gender differences and found that females' achievement was on average less than males' in the more factual type of essay, but that females outperformed males in the explanation type of essay. However, the point made here is that neither the males nor females could do the same justice to their physics knowledge in the essay question which they could demonstrate in other sections of the paper.

Apart from essay questions in the examinations, Whitehouse and Sullivan (1992) showed that the nature of all other questions in the physics examination had changed over the last six years. Where once calculation questions comprised 67% of the paper in 1987, they comprised 32% in 1990 and 40% in 1991. In that period the explanation type question increased from about 20% in 1987 to almost 40% in 1990 and 1991 because explanation was introduced in all sections of the paper including the short answer and the calculation questions. It seemed then that for this research, a strategy for teaching and learning the explanation genre was needed.

Language Needs of NESB Students in Science

The concern has been expressed that a number of students who formerly selected science at school level and who were successful at gaining university entrance may be disadvantaged by the need to pass the English literacy assessment. Sloniec (1992) reported this concern as follows:

With the introduction of the Writing Based Literacy Assessment as a requirement to achieving Stage 1 of the South Australian Certificate of Education, concern has been expressed by teachers, students and community members that this may disadvantage students from non-English speaking backgrounds. Whether this is the case or not needs to be monitored carefully by both the Education Department and the SSABSA. What does remain clear is that the issue of English language and literacy development continues to be crucial for students from non-English speaking backgrounds, and that this must remain a major systemic priority. (p. 17)

The population data from the 1986 census were that 917,000 people lived in the urban area of Adelaide, representing approximately 90% of the population of South Australia (Australian Bureau of Statistics, 1988). Of these 461,891 were from both parents born in Australia, that is 50.4%, including approximately 5,700 (0.6%) of Aboriginal or Torres Strait Islander descent. Therefore the proportion of those with some degree of bi-culturalism, from either overseas or Aboriginal or Islander culture, was approximately 50% including approximately 13% who were actually born in non-English speaking countries.

It was difficult to assess the proportion of NESB students in upper secondary science classes as no such data were available. It was possible to estimate the proportion of NESB students in science subjects from the data for university enrolments which excluded full fee paying overseas students, according to the Information Bulletin 91/4 of the Office of Tertiary Education (1991). It would seem that the proportion of NESB university students enrolled in science based courses, varied between 20% and 35% (of approximately 12,000 students) compared with the enrolments in non-science based courses, which were between 8% to 13% (of approximately 30,000 students) as shown in Table 1.4. The pre-requisite for enrolment into science-based university courses was a science course at the Year 12 level, and hence the data can be used as conservative estimates of the proportions of NESB students in school science courses (and school non-science courses), if one makes the reasonable assumption that the rates of entry to University were approximately the same. Hence the composition of NESB students in school science courses can be considered to be in the range of 20% - 35%. This considerable proportion emphasises the need for strategies to assist in meeting the language needs of these students in the new era of focus on English competency.

Table 1.4
Non-English Speaking Background Students in University Courses

Science-based courses	NESB student enrolment (%) (n>12000)	Courses with a lesser science base	NESB student enrolment (%) (n>30000)
Computing & Maths	34.9	Agriculture	8.3
Engineering	28.3	Nursing	9.3
Health(not nursing)	25.2	Education	12.3
Architecture	21.2	Humanities	12.7

These data were collected before the impact of the Writing Based Literacy Assessment (WBLA) (SSABSA, 1990) would become known, because the first cohort would not begin university enrolment until 1994. Considering the possible negative impact of the WBLA on NESB students, it further strengthened the need to develop subject specific strategies for enhancing literacy for NESB students.

In the case of Aboriginal and Islander students an under-representation exists in all university courses and particularly in science based-courses, and by implication, upper secondary school science courses. In 1983 fewer than 12 such students had matriculated; there were only 10 registered nurses and 30 teachers; there were no graduates in law until 1985 and by 1992 still no aboriginal graduates in medicine or dentistry. The under-representativeness of Aboriginal and Islander students in science at the secondary level is a result of many complex factors, including poor retention rates of students to Year 12, being 21.5% compared with 59.1% of all students in 1988 and still only 27.5% compared with 76.8% for all students in 1991.

A study of the complex factors leading to these poor retention rates is beyond the scope of this research. However, the strategies proposed in this study for improving scientific literacy were made adaptable for meeting some of the differences in cognitive styles resulting from bi-cultural experiences. The research of Christie (1991) indicated the importance of being aware of the different ontologies, or meaning systems of knowledge of science, established according to the nurturing culture.

The importance of recognising the cultural background of students in developing literacy in subject areas has been extensively reported by linguists such as Cambourne, Dawe, Houston and Newman, cited by Wales (1990), and others. The difficulty outlined by linguists is that internalised rules of language syntax in a child's first language are not necessarily the same as those in the dominant culture. Thus students are required to be continually adjusting and reorganising the internalised rules at the same time as they are acquiring a cognitive organisation of new knowledge. Normal literacy in Western societies according to Wales (1990) is "based on prior native speaker competence (i.e. internalised knowledge of the rules) in the relevant language" (p. 167).

A caution given by the linguists for developing literacy is to recognise that NESB is not a unidimensional category of students, but that each student has different problems in the acquiring the second language. Some have migrated after a childhood in their first country, some have migrated in early childhood and have very little background knowledge of either culture, some have been born in Australia, while other Australian-born children may have a different home language, such as some Aboriginal and Islander students. According to the linguists, it is important to recognise those NESB students who have been born or lived in Australia a number of years, are characterised by apparent oral fluency particularly when among their peers, but lack minimal skills in the formal language. This applies to the use of written language, particularly in the case of science with its specialised vocabulary and the subject specific language register.

Interim Summary

In the previous sections, review and discussion of the Gilding Enquiry, the WRAP, the essay results in public examinations, and the language needs for NESB students, has demonstrated the need for a scientific literacy development plan for senior secondary science classes, particularly in physics classes where the need seems greatest. However, to be effective the plan would need to address a number of specific needs to be practicable within the regular upper secondary school context. First, the plan would need to be readily adaptable to teachers' needs, to be easily modified, and to be integrable into the teachers' course outlines for approval by the Senior Secondary Assessment Board of South Australia. Second, it would need to met the immediate requirement of Year 11 students and teachers for a method to fulfil the WBLA requirements. Third, it would need to serve as a way of preparing for wider literacy requirements in the course objectives as well as specific tasks including essay writing, in the public examinations.

Among other requirements of the plan is the need to be readily accessible by students from non-English speaking backgrounds, who may be disadvantaged by the new South Australian Certificate of Education literacy requirements if subject specific strategies to improve literacy are not implemented. These subject specific strategies would need to inculcate the use of examples of the language register of science. The need for more practice in extended writing and the provision of more variety in writing tasks, as described in the WRAP reports, could be met with specific strategies for writing in the different scientific genres. It would seem possible to include scientific and technological issues within contextual readings in the plan in order to stimulate students' social concern as part of their science education.

In summary then, the scientific literacy development plan would need to be suitable for all physics students at the Year 11 level in regular course physics topics if it is to bring about a general improvement in scientific literacy and specifically in extended writing in physics topics. The plan would be adaptable for use in other science courses.

Purpose of the Study

The purpose of the study was fourfold: to investigate the meaning of scientific literacy and to formulate a comprehensive definition of the term; to determine and develop the components of a Scientific Literacy Development Plan (SLDP) for upper secondary science students; to trial the SLDP for its general effectiveness in relation to students' performance in explanation writing, and teachers' integration into course schedules; and then to analyse its specific effectiveness in relation to elements of the definition of scientific literacy.

Research Questions

The fourfold purpose of the study is formulated here in four distinct research questions.

The first research question. How is scientific literacy to be defined, and what are its elements?

The second research question. What are the practical components of SLDP for Year 11 physics students? This question implies a further sub-question: How are these components to be developed, refined and integrated into a cohesive plan?

The third research question. What is the general effectiveness of SLDP? This question implies further sub-questions: How can general effectiveness be assessed? Does the general effectiveness of SLDP apply across all levels of student writing ability? Can the SLDP be incorporated into individual teacher's course schedules?

The fourth research question. Is the effectiveness of SLDP related to specific elements in the proposed definition of scientific literacy? (Note the use of 'elements' for parts of the definition and 'components' for the SLDP.)

Research Design

Fundamental to the study was a literature survey into the use and meaning of the term scientific literacy and to develop a theoretical framework for a comprehensive definition. This study was followed by the development of a practical application of the definition namely, the SLDP, which was then tested and refined through a number of phases of classroom research. This research method is described fully in Chapter 4 and the following paragraphs serve as an overview.

Defining Scientific Literacy

The first research question, defining scientific literacy, was answered through a literature review of the contexts and various meanings of the term as described in Chapter 2. These meanings seemed somewhat piecemeal and disjointed so a comprehensive definition was developed by means of synthesising relevant theories as described in Chapter 3.

The bases for defining scientific literacy were situated within cognitive theories of mind, theories about the discourse of science, the language register of science and cognitive writing processes. Then to make this definition applicable, the integration of concept development strategies and language acquisition strategies was required for the formulation of a scientific literacy development plan, the SLDP. It was necessary to make the theory-based comprehensive definition operative by applying it to Year 11 physics in the South Australian context. This led to the proposal of a scientific writing strategy called the HyperCard Pathways (HCP) model of writing which allowed for trialling scientific literacy within the terms of the definition. The fundamental processes of literacy as described in Chapter 3 mean activating the human cognitive domain prior to expression in the linguistic domain. Therefore the definition for scientific literacy formulated in Chapter 3 is:

Scientific literacy is the human function of activating the cognitive processes in the discourse of science and communicating this discourse in a form of language register of science.

This is the end product of investigation into the first research question and the method was one of reviewing the literature, and discussing the findings with science educators, linguistic experts and teachers. The elements of the definition for later discussion are activating the cognitive processes, engaging in the discourse of science, using a language register of science, and communicating in written mode.

Constructing a Scientific Literacy Development Plan (SLDP)

At the commencement of constructing SLDP, advice from literacy education experts was sought and the relevant literature reviewed. From these enquiries it seemed that four types of activities were central to an effective plan. They were activities involving language acquisition, concept mapping, constructive dialogue and extended writing. To test the proposal for a hypertext form of writing, described more fully in Chapter 3, the activities were linked within an application of the HyperCard computer software package and called the HyperCard Pathways (HCP) modules specific to topics in physics. These SLDP activities are illustrated in Figure 1.1.

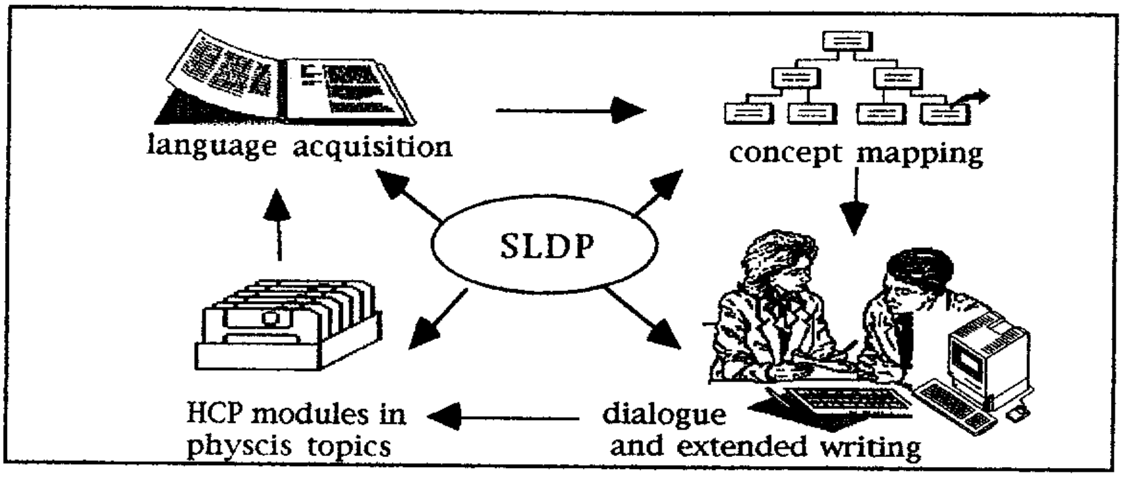

Figure 1.1. Illustration of the activities of SLDP.

These activities were then made specific to topics within the Year 11 physics course and modules for each topic were constructed within the HCP model of writing. These are called the HCP modules. The modules can be used at any stage within teachers' course schedules without any sequential order and were tested as part of the effectiveness of SLDP for teachers, to answer the third research question. The expected end-product of using each module was a student constructed concept map and piece of extended writing that would meet the requirements of WBLA as well as provide the data for the above research questions.

The SLDP was continuously redeveloped, refined and supported with lesson plan materials throughout three phases of classroom research described in the next section. The components of SLDP are described in Chapter 5, and their subsequent development and refinement are described in Chapters 6 and 7. Reference to Figures 5.3, 6.3, and 7.2 would provide an advance organiser for understanding the development of SLDP.

Testing the Effectiveness of SLDP

The effectiveness of SLDP was tested in three phases of classroom research. The first phase was to develop and trial SLDP in a pilot study and then review the results of student performance and the reactions of teachers and thesis supervisors (named in the Acknowledgments). The trial was carried out over a four week period in a small number of classes at the end of which pieces of students' extended writing were collected. A small number of classes not involved with SLDP served as a control group for comparison of results.

The second phase was to refine and further develop the SLDP through an extended study into the effects of integrating the SLDP strategies into a number of physics topics. This is called the first extended study and is described fully in Chapter 6. The trial of the first extended study was integrated into each teacher's semester course plan and hence different topic modules were used in different schools to test SLDP. A larger number of schools (than was the case for the pilot study) was required for both the experimental group and the control group in order to achieve a wide cross-section of the population of physics students. The research was planned as a time-series repeated measures design using a combination of quantitative and qualitative data gathering techniques to investigate the effectiveness of SLDP as required by the third research question and its sub-questions.

A second extended study was planned to take into account the refinements and further developments of SLDP and this constituted the third phase of the project, described in Chapter 7. The data collected from this second study were used to analyse how the effectiveness of SLDP related to specific elements in the proposed definition of scientific literacy as required in the fourth research question. The tasks of sample selection, collection of data, and analysis of results are described in Chapters 5, 6 and 7 which deal respectively with the pilot study, the first extended study and the second extended study.

Significance of the Study

The significance of this research is discussed according to its outcomes, which are the comprehensive definition of scientific literacy, a plan to make the definition applicable, the SLDP with its flexibility and supporting materials, the HCP topic modules and the assessment scheme for students' extended writing. The products of the research would seem to be significant for further research into the area of scientific literacy and for further development of course materials.

The Comprehensive Nature of the Definition.

A comprehensive definition of scientific literacy embedded in a theoretical framework was proposed and made operational with practical strategies. This is opportune in the present climate in South Australia where the commencement of a new focus on literacy across all subjects has been undertaken. The definition takes into account not just linguistic elements but scientific ones as well. It is anticipated that science teachers may find assistance in this definition for the shaping of curriculum objectives and assessment plans within the South Australian Certificate of Education.

The Flexibility of SLDP

The SLDP was constructed as a series of lessons and the program made flexible so as to be assimilated at any point in a teacher's course schedule. The number and type of lessons required could be modified according to the requirements of teachers and students. Supporting materials for teachers may be a significant help to them as many pre-service science teacher training courses contain little teacher training in language skills.

The Design of HCP Modules

The development of topic modules in physics using HyperCard enables teachers to modify the modules in various ways to suit their needs. This is a significant innovation in the area of computer-assisted learning packages, as many current packages are designed to be used only as designed rather than to be easily modified by the user. The design of the HCP modules was made for teachers (rather than computer experts) including those with limited experience in HyperCard or with computers. This enables them to modify the modules, while preserving some form of control over student access.

The Assessment Scheme for Extended Scientific Writing

The production of an assessment scheme for extended pieces of scientific writing has practical significance for teachers independent of the use of SLDP strategies. During this research project a grading scheme was developed that had relevance for science teachers who wished to avoid the trap of assessing an essay merely in terms of the number of scientific ideas, and who were dissatisfied with current schemes which focused primarily on linguistic features. This scheme enables teachers to grade the quality of scientific writing in the explanation genre of essays according to criteria related to both scientific and linguistic features.

Significance for Further Research

The SLDP process may serve as a model for further research into scientific literacy. The literature review takes a further step in the direction of categorisation of types of references to scientific literacy according to meaning and context. A similar categorisation process may be used in further research. The process of synthesising relevant theories may also be applicable to on-going research into these theories. The method of mixing developmental research within three phases of developing SLDP and empirical research to establish the effectiveness of SLDP, may serve as a model for on-going research in this area.

The products of this research include lesson plans, computer discs and supporting materials, which may provide assistance to teachers to develop further modules in this curriculum or topics in other science subjects.

Limitations of the Research

Although a comprehensive definition of scientific literacy was developed in this research, its application in this study was limited to investigations with physics students in the main, with samples of the Year 11 level students from a small number of schools. The focus in this research was on topics in physics with a later limited extension into chemistry. It was not possible to repeat the research for all science subject topic areas given the constraints of time and resources, but the extension into chemistry suggests that it could be used for other subjects. Another aspect of this limitation was that Year 11 was the only year level that could be chosen for classroom research because of the modular nature of the physics course outline at that level. Access at the Year 12 level would present difficulties to teachers and students because of the greater integrated nature of the course and the need to prepare for the more highly weighted sections in the public examinations. Access to Year 10 was a possible option, but this was precluded because there was no common course structure across a range of schools in any one of the science subjects, which would limit the scope for comparison between a group of trial schools and a group of control schools.

Another limitation was the small number of schools and hence the small number of students that could practicably be involved in the classroom research phases. This was determined by the workload for the researcher, which included recruiting and inducting the participating teachers, visiting school principals and computer network managers, obtaining permission from school authorities, preparing the SLDP materials, the HCP modules, and supporting lesson plans, assisting participating teachers in the implementation of SLDP, collecting and assessing student writing pieces, meeting with participating teachers for reviewing the assessment of student writing, giving feedback to all students about their extended pieces of writing, and writing reports for participating teachers and school authorities after each phase of the classroom research.

A further limitation was that schools were not able to be selected randomly, and hence the representativeness of schools used for experimental and control groups must be questioned. The selection of schools was determined by the constraints of available computer equipment, the willingness of school principals and the teachers to participate, and the location of schools. It was impracticable to include country schools given the constraints of workload on the researcher and the limited availability of travel resources.

These limitations mean that the results of the study must be interpreted within the context of Year 11 physics in the schools where the study was carried out. However, it is likely that the schools with appropriate computer equipment could also use SLDP effectively if teachers were prepared to integrate the program of lessons into course schedules and to adapt the HCP modules to their needs.

Thesis Overview

Following this introduction to the research study, Chapter 2 presents a literature review of the contexts in which the term scientific literacy has been used. The wide ranging applications of the term are explained and some examples of tests used to measure scientific literacy. Chapter 3 reports a synthesis of relevant theories in order to derive a philosophical meaning of scientific literacy and propose a comprehensive definition. This definition is then applied to cognitive writing processes and a new model proposed for scientific writing called the HyperCard Pathways (HCP) model of writing.

Chapter 4 describes the research design of the study for the empirical aspects which consists of a combination of qualitative and quantitative methods. Chapter 5 reports the initial development of the components of SLDP and the results of a pilot study. Chapter 6 gives an account of the first extended study including the further development and refinement of SLDP and the HCP modules. The development of an assessment scheme is described and applied to the results of the trial.

Chapter 7 reports further development and refinements of SLDP and the outcomes of trialling in the second extended study. The data are analysed for evidence of the effectiveness of SLDP for improvement in scientific writing performance. Chapter 8 summarises the findings of the study and draws conclusions from the research outcomes, taking note of its limitations. The educational significance of the study is discussed and implications suggested for teaching and further research. An overview of the chapters is presented in Figure 1.2.

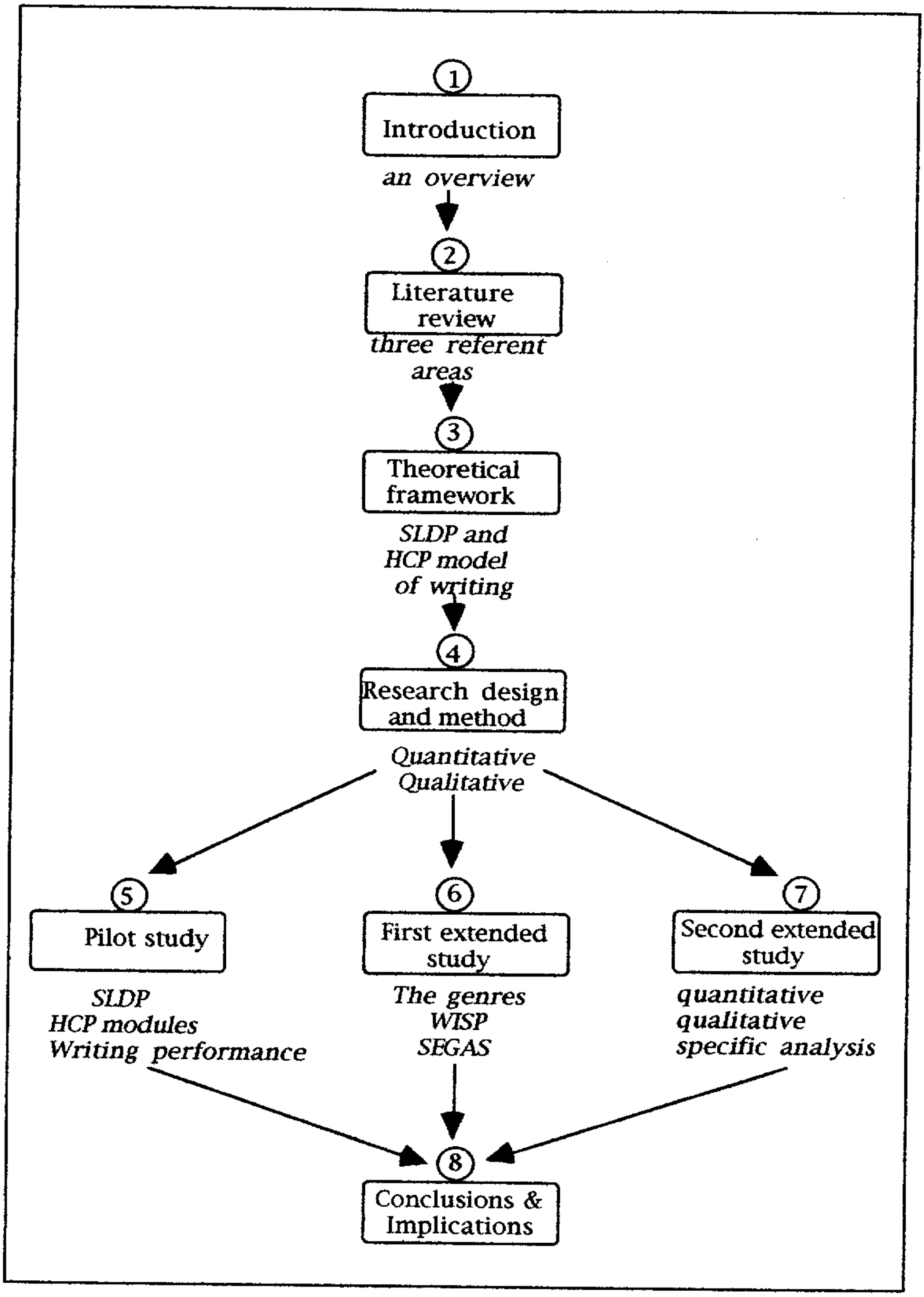

Figure 1.2. An overview of the thesis.

CHAPTER 2
SCIENTIFIC LITERACY: A LITERATURE REVIEW

Introduction

This literature review follows the method of Pella, O'Hearn and Gale (1966) in establishing the early reference literature. Journals were searched for references to the term scientific literacy, and then a framework of so called 'referent areas' was devised in which to locate the meanings of the term. This review then proceeds to the more recent literature and reports new meanings of the term scientific literacy. The evolution of new meanings for the term required a new framework of referent areas to be devised. This chapter presents a framework which subsumes the original referent areas of Pella et al. (1966) and incorporates the more recent references. The chapter concludes with a discussion of the directions in which the meaning of the term scientific literacy is evolving and how a comprehensive definition can be formulated.

The Early Reference Literature

The term scientific literacy has been used in the literature with a variety of meanings. The first known collation of references to the term was made by Pella et al.(1966) who systematically searched The Reader's Guide to Periodical Literature and the Educational Index from 1946 to 1964 for references to the term scientific literacy. The researchers devised a framework of six referent areas in order to facilitate their search and to discuss the content of 100 relevant source documents. The referent areas devised were science and society, ethics of science, nature of science, conceptual knowledge, science and technology, and science and humanities. Using these six referent areas, a definition of a scientifically literate person was given by Pella et al. (1966) as follows:

> The scientific literate individual presently is characterised as one with an understanding of the (a) basic concepts of science, (b) nature of science, (c) ethics that control the scientist in his [sic] work, (d)

interrelationships of science and society, (e) interrelationships of science and humanities and (f) differences between science and technology. (p. 206)

This definition was supported by the frequency of the six referents used in the literature as follows: science and society (67%), ethics of science (59%), nature of science (51%), conceptual knowledge (26%), science and technology (21%), science and humanities (21%). However, since the time of that study in 1966, other meanings of the term have been developed as will be explained later.

Showalter (1974) adopted a different approach to defining the term. Instead of defining the term as such, Showalter identified characteristics of a scientifically literate person, which later became the way that certain curriculum documents defined the term (Board of Secondary School Studies, Queensland Department of Education, 1977). Thus a scientifically literate person demonstrates seven characteristics. Such a person understands the nature of scientific knowledge, accurately applies science concepts, uses processes of science in problem solving, has values that are consistent with those of science, understands the interrelationships between science and technology, and develops aesthetic appreciation of the universe. Some of these characteristics are challenged in the more recent literature. For example Chalmers (1990) and O'Hear (1990) query whether there are consistent values among scientists, whether there is a consistent scientific method or whether scientific laws represent reality and the notion of an absolutist world view. Even the notions of relativistic causality and determinism are debated by scientists (Penrose, 1989). Thus a scientific literate person according to the Showalter characteristics may not in fact be literate in the discourse that admits a relativist interpretation of science. (These notions are discussed further in Chapter 3.)

The next major attempt to elucidate the term was the 1983 journal edition of Daedalus 112 (2), in which eleven authors addressed the theme of scientific literacy. The general thrust of the journal theme was to show how scientific illiteracy impedes social and economic progress and alienates individuals who cannot access the technologies. Walberg (1983) discusses scientific literacy in economic terms. Miller (1983) believes the term has describes an attitude towards the processes in science and links this with the processes in a democratic society. Nevertheless Miller (1983) says there is little consensus on a comprehensive definition of the term. Prewitt (1983) discusses scientific literacy as the public understanding of science so that there would be a democratic participation in the technological society. Childs and Hickman (1983) define scientific literacy simply as the public understanding of science, and use this definition to support the claim that knowledge of human genetics is central to scientific literacy because this knowledge is necessary for making decisions that pertain to daily living. In contrast, Kemeny (1983) argues that an essential prerequisite for scientific literacy is computer literacy. Rowe (1983) discusses scientific literacy in terms of scientific wisdom to include the analysis of values, prediction of consequences, and implications for actions as necessary components for popularly based decision making. Arons (1983) defines scientific literacy as a range of abilities within the scientific processes to achieve a wide scientific literacy. It is clear from this brief resume of one entire issue of Daedalus that a consensus about the meaning of the term scientific literacy is lacking. The summary provided by Graubard (1983) states:

> Even the most casual examination of this issue of Daedalus will suggest that the term 'scientific literacy' lacks all precision, that there are no generally accepted criteria for determining what an individual needs to know to be called scientifically literate, or why it is vital (or even important) for great numbers of Americans to wish to achieve such literacy. Basic competence in science, another way of defining scientific literacy, is clearly an elusive concept, made all the more so by the fundamental ambiguity, even among educators, about the kinds of scientific knowledge and understanding that it is [sic] useful for ordinary citizens to command. (p. 231)

Further review of the literature indicates continuing multiplicity of meaning of the term. For example, there has been the growth of a large amount of literature in the area of language and communication skills, and this is regarded by some as being the prime necessity for scientific literacy (Touger,1991). This in turn has given rise to post-modernist critical theory in which literacy is regarded as a social construct to ensure class dominance (Martin, 1985, 1991).

To take into account the evolution of the term since the time of the Pella et al. (1966) study, this literature review uses a framework of three referent areas in order to compare and contrast the multiple meanings of scientific literacy as currently used. It is possible to regroup the original six categories (Pella et al., 1966) into two areas and to add a third referent area emerging from the more recent literature, dealing with language and communication skills in the pursuit of scientific literacy. Within in any one reference, there are of course degrees of overlap between the three referent categories. Nevertheless, this method of categorising references is helpful for illustrating the common strands among the multiple meanings of scientific literacy.

Three Referent Categories

The three referent categories used in this review are first, scientific literacy referring to the level of knowledge and understanding of the nature, the concepts, and the processes of science; second, scientific literacy referring to the level of concern expressed by citizens about the impact of science on society; and third, scientific literacy referring to the level of language skills used in the communication of science.

Level of Knowledge and Understanding of Science

The first referent category is that scientific literacy is the level of knowledge and understanding of the nature, the concepts, and the processes of science. The three referent areas of Pella at al. (1966) of science and technology, conceptual knowledge, and nature of science, are subsumed under this more general meaning of scientific literacy. This view of scientific literacy leads to the assumption that it can be defined, measured and described in terms of a taxonomy of cognitive and psychomotor skills. In this referent category knowledge and understanding of science includes declarative and operational knowledge, knowledge of science processes, non-formal and informal knowledge, and technological knowledge and competency in technical skills. These aspects are like flavours to the general notion of scientific literacy being primarily the level of knowledge and understanding about science. Teaching for scientific literacy in this referent category is the enhancing of the ability to relate science content to the processes of science (Renner and Stafford, 1979).

Declarative and Operational Knowledge

Scientific literacy is defined by Arons (1983) as a range of abilities such as being able to recognise scientific concepts, to comprehend the distinction between observation and inference, to understand the meaning of theory in the scientific domain, and to develop enough basic knowledge to allow reading for interest. Other abilities, such as awareness of the interaction between science and society and awareness of close analogies to other forms of learning which would form part of the second referent area, are discussed later. The prime focus for scientific literacy in this category is the knowledge and understanding of science. Arons (1983) draws the distinction between declarative knowledge (the facts) and operational knowledge (understanding the source of declarative science). Cognitive development through reasoning processes is considered to be more important than rote memorisation. Arons (1983) says that teacher education in the understanding of science is more essential than continual development of new curricula materials. Arons' recommendations for improved scientific literacy included reforming teacher education practices by addressing the problem of the inadequate understanding of science by trainee teachers.

An investigation undertaken by Lucas and Tulip (1980) is an example of a study which defines scientific literacy in this category. The authors attempted to establish the status of scientific literacy among three groups of secondary school students in four Queensland high schools. For the purpose of that study, scientific literacy was defined as the set of scores obtained by students in three tests that were devised to measure a number of characteristics of scientific literacy similar to those used by Showalter (1974). The battery of tests (Fraser, 1978, 1980) administered were previously unrelated to Showalter's characteristics but were linked by Lucas and Tulip to the characteristics scientific literacy. The achievement in these tests constituted the degree of scientific literacy, according to the authors (Lucas & Tulip, 1980):

> This pragmatic approach resulted in the operationalisation of the term scientific literacy in terms of achievement on the particular battery of

tests selected rather than strictly along the lines of Showalter's (1974) definition. (p. 5)

The results were reported to be similar to those obtained by Fraser (1978). No attempt was made to integrate or specify the relative importance of each characteristic of scientific literacy and hence no wholistic notion of scientific literacy emerged from the study other than reporting "the disappointingly low status of scientific literacy among Year 12 students" (p. 22).

A more recent example of the use of scientific literacy as a statement about knowledge is found in the Rosier and Banks (1990) study of the scientific literacy of Australian students. Scientific literacy was regarded by Rosier and Banks as the level of test scores achieved in science knowledge tests. The results of the tests used in the Second International Science Study (Rosier, 1987) are reported as the "scientific literacy of Australian students" (Rosier & Banks, 1990, p. iii). Scientific literacy is based on performance in specific tests in the sub-disciplines of science. Correlations are made with language background, parent occupation and school resources. The results of Australian students are compared with those from overseas, as well as being internally compared between the States. The conclusions drawn by Rosier and Banks (1990) are that there are sufficient concerns about the coverage of science curriculum, activities during science lessons and student achievement in tests, to warrant improvements in science education. Improvements in scientific literacy would in turn increase the economic performance of Australia relative to other countries, according to the authors.

Knowledge of Science Processes

Aikenhead (1979) described the course " Science: A Way of Knowing" as a response to the paucity of materials designed to enhance scientific literacy in Canada. The three sections of the course (different ways of knowing, science as one way of knowing, and the interaction of science and society), employ diverse instructional materials and teaching methodologies. The knowledge of scientific processes is allied to the learning theories of Bruner, Piaget and Vygotsky for concept formation, in order to develop a variety of inquiry skills and personal competence in the understanding of the processes of science.

Hughes (1990) reports on the Understanding Science Project which received approval from the then School Examination and Assessment Council (UK) for trial leading up to the 1992 public examinations at Westminster School. The project is built around a core of knowledge about science processes such as observation, data collection, experimentation, and a series of options about scientific topics of current interest. The core is expected to take about half of the 135 hours allocated to the course. The options about societal issues such as AIDS, greenhouse effect, are analysed according to the scientific method, reliability of data collection, validity of conclusions and correct interpretations. The intention of the course is for enhancement of scientific literacy as shown by better analysis of data, expression of better informed and more balanced viewpoints, and the raising of social and moral problems during class discussions.

The Understanding Science Project is an attempt to bring about scientific literacy through cognitive development as well as to raise concern about societal issues. Communication skills are regarded as important by Hughes but little information is given about strategies for developing language skills. The project addresses other referent categories such as communication, but its primary focus is on the understanding of the science processes.

Informal and Non-formal Activities in Science

The Rand Afrikaans University Scientific Literacy Research project (Maarschalk, 1988) advocates the use of informal methods for scientific literacy as well as the formal and non-formal methods of science education. Informal methods are those that come about spontaneously, such as family or peer group discussions following some event such as a TV show, or from recreational pursuits not organised explicitly for science education. Non-formal methods are those that are outside the sphere of the formal curricula but organised for science education, such as field trips and museum visits. Formal methods are within the normal curricula such as lessons and laboratory practicals. The meaning given by Maarschalk for scientific literacy is that "a scientifically literate person wants to do and actually does something of a scientific nature, e.g., watch a science TV show, visit a science club, collect butterflies, etc." (p. 139) which is an application of the informal methods. The project inquired into cognitive preference as a basis for scientific literacy, and this was manifested by individuals being motivated to seek informal knowledge of science such as that stimulated by events such as Julius Sumner Miller's demonstrations, or engagement in hobbies.

To achieve scientific literacy as knowledge gained through non-formal and informal methods, information must be presented by informal and non-formal means. Such an example is the attempt by Hazen and Trefil (1991) in the book Science Matters. Scientific literacy is defined as "the knowledge you need to know to understand scientific issues. It is a mix of facts, vocabulary, concepts, history, and philosophy" (p. xii). The book attempts to put these concepts into the lay person's language and this distinguishes it from textbooks in physics. However, it was criticised by Durant (1991) for ignoring one of the most relevant aspects of science to the lay public, that is, medical science. Durant states that "because it ignores this real world of scientific practice, Science Matters provides only part of what non-scientists need to achieve scientific literacy" (p. 528). In support of informal access to science, Zen (1991) promotes a similar widening of the knowledge base by informal means for scientific literacy and advocates the demystifying of science by providing access to a communal knowledge base.

Jane (1990) argues for attention to be paid to scientific and technological literacy in the wider curriculum rather than being restricted to the science subjects. As an example of this, Jane (1990) proposes using the subject Australian Studies, a compulsory subject for the Victorian Certificate of Education, as a vehicle to provide "the opportunity for increasing scientific and technological literacy" (p. 157). Jane argues that "science and technology in schools often present an incomplete picture" and that through Australian Studies, "people-oriented activities and the human dimension of science and technology" can be presented (p. 158). An added bonus for this approach is that of promoting higher proportions of females in pursuit of scientific and technological literacy. These examples are used to support the notion of scientific literacy being the level of engagement in informal and non-formal activities in science.

Technological Knowledge and Competency in Technical Skills

As a result of surveys in Australia, Eckersley (1987) found that few leaders in business, government and trade unions, perhaps one in ten, considered themselves as being sufficiently informed about science. Eckersley suggested that gaining this form of knowledge is essential to economic and social well-being. Crean (1990) supports the view that literacy in science and technology is linked to national economic development and hence advocates the preparation of a technically skilled and competent workforce. This is the context in which Jane (1990) situates scientific literacy: "An important reason for attempting to develop scientific literacy in students is that in order to understand modern technology, citizens need to be scientific literate" (p. 152). However, this form of scientific literacy is applied in the context of curricula outside that of the conventional science curricula knowledge as discussed later.

In the American context, Brooks (1991) suggests that scientific literacy can be measured in terms of economic outcomes arising from competence in technical and mathematical skills. Two groups of educators in the USA have attempted to construct the elements of scientific literacy. The first is the group, the National Research Council on Science and Technology education, responsible for 'Project 2061', which is supposed to give scientific and technological superiority to Americans by that year (National Research Council on Science and Technology Education, 1989). The recommendations require that a common core of learning be limited to the skills and ideas that will enhance technical understanding. It is both a knowledge-based and skills-based understanding of scientific literacy. Technical literacy, as it is called, is to be made accessible to a much larger fraction of each age cohort as it comes through the education system. The second group of educators, the National Research Council Mathematical Sciences Education Board, adopts the position that mathematics is the foundation of scientific and technical literacy and hence recommends that the syllabus for all education should contain elements of mathematical skills. Brooks (1991) concludes that technical and mathematical competency are the requirements for increasing scientific literacy. Brooks quotes the scarcity of people with technical and mathematical competency in the post-Sputnik race, and after the Three Mile Island accident as practical examples to illustrate the need for this form of scientific literacy.

In an attempt to draw the connection between technological knowledge, technical skills and scientific literacy, Kenny (1988) speaks of a techno-scientific literacy in order to show the close connection between the two disciplines. Mastery and competence are juxtaposed to draw the distinction between being a scientist or engineer and being a user of science and technology:

> It makes sense to distinguish between the competence and mastery necessary for a person to merit the description of scientist or engineer, on the one hand, and the kind of understanding of scientific and technological processes and products which may then justifiably be described as literacy, on the other. (p. 23)

However, according to Kenny (1988), such technological knowledge does not provide the totality of the human endeavours: "The claim that approximately half the scientists and engineers on this planet are currently engaged in military and armaments enterprises should at least dictate that we proceed with caution" (p. 25). This caution leads to the discussion about the references to scientific literacy being the level of concern about the impact of science in the next section.

<u>Interim summary</u>

The references cited in the above paragraphs generally support the notion of scientific literacy being primarily the level of knowledge and understanding of science, whether as declarative and operational knowledge, knowledge of science processes, knowledge from informal and non-formal activities or as technological knowledge and competency in technical skills. The second referent category, loosely described as scientific literacy, is primarily the level of concern about the impact of science and is discussed in the next section.

Level of Concern about the Impact of Science

The level of concern in the literature about the impact of science seems to be expressed within one or more contexts: societal, cultural and ethical contexts in science. These sub-categories are discussed with appropriate references in the following paragraphs, keeping in mind that there are broad areas of overlap between all referent areas.

Concern within a Societal Context

Pella (1976) regarded scientific literacy as having a societal context just as does literacy in social studies, literacy in humanities and literacy in technology. Literacy in science, according to Pella (1976), must have a human frame of reference. The task of science educators is to facilitate the public access to science so that more citizens will become more concerned about the impact of science on society. Pella (1976) saw one of the faults of science teaching at the time to be that "it is still taught to produce big scientists and little scientists, rather than literate citizens" (p. 98). This means there must be a dimension to scientific literacy that helps people to understand what they already know, and to ensure that science becomes functional in the lives of people. Pella (1976) stated that world problems had social and humanistic implications for science and hence they required the general population to be more concerned about the impact of science. This context of scientific literacy drew attention to the place of humanistic implications in scientific literacy, and the level of concern expressed was regarded as the measure of scientific literacy.

In a similar way, Aikenhead (1985) saw the level of collective decision-making as the measure of scientific literacy. Before collective decision-making can be achieved, science must be seen in a social context. The values suggested by Aikenhead (1985) for acceptance of the social context were modesty, accessibility, consideration of non-violent, non-coercive and non-manipulative research, and harmony with nature. Thus a scientific literate person would manifest these values in collective decision making. There is also the political perspective to scientific literacy, seen by Aikenhead (1985) as "literacy is not enough; information is not enough; people must have power to act on what they learn" (p. 460).

Shortland (1988) expressed the opinion that societal concerns form part of scientific literacy. Shortland identified six components of scientific literacy which included historical origins and the epistemological and practical values which they embody. Shortland argued against a scientific literacy for the elite of science and advocated scientific literacy for "ordinary people". Scientific literacy "is the way in which ordinary people, not research scientists or novelists or politicians or policy makers, relate to the world of science as they experience, meet and confront it" (p. 315). Scientific literacy, according to Shortland (1988), was the level of participation by concerned citizens in scientific decision making through political means. "In a word, to be scientifically literate is to become an active and effective citizen" (p. 315).

The design of interdisciplinary courses such as that described by Adams, Roberts and Walsh (1989) at Bradford College, Massachusetts, is an example of the interpretation of scientific literacy within a societal context. This course apparently was offered as a history and philosophy based course from 1982 to 1986 and attracted low enrolments. Its name was then changed to "The Individual, Science, and the Environment" and it became immediately successful. The reason for the success, according to Adams et al. (1989), was that it tapped into scientific literacy within a societal context.

> The vast majority of students at Bradford College are not science majors who take this course because it is required. Many have previously had poor experiences with science and science courses and feel they 'cannot do science'. However, they soon see that the course's main goal is to help them understand the world around them from an interdisciplinary perspective, and that many current issues they are interested in are based in science. (p. 410)

Other interdisciplinary science courses promote scientific literacy within a societal context. For example, courses described by Yager (1989) and called 'applications' courses, engender creativity skills, positive attitudes, and applications to the real world of living. In these courses the aim was to enable graduates to become science "attentives", that is "those people who express interest in science, have a knowledge of science, and are able to deepen interest and knowledge in the subject by themselves" (p. 273). A comparative study was conducted by Yager (1989) at the University of Iowa, in which the performances of 30 students in the 'applications' course in biology were compared with the performances of 44 students in the general biology course. In the measure of acquisition of concepts there was little difference between the two groups. In the measure of application of concepts to new situations, and in the measure of the quality of creativity skills, there was significantly more growth in the applications course group than in the general course group. This result was seen as success in achieving scientific literacy in this context.

Concern within a Cultural Context

Scientific literacy must include the components of civic science literacy and cultural science literacy, according to Hetherington (1982). An increased level of civic science literacy is regarded as a necessity for democracy. Science is seen as a social construct and therefore it should be in the hands of the people rather than in the hands of an elite if it is to serve the processes of democracy. A scientifically literate person understands that the actual history of science indicates a considerably different story from that presented by descriptions of the classical scientific method. Hetherington (1982) advocates that students should see science as a human and subjective enterprise just as music or art is perceived as human and subjective.

An example of scientific literacy within a cultural context is provided by Christie (1990). The theme of cultural integration of scientific literacy into Aboriginal culture is offered as an alternative to what is called Western science. In Aboriginal science, thousands of seemingly unrelated pieces of information are organised through complex webs and levels of metaphor which are utterly alien to Western taxonomies. Incorporated in this environmental sensitivity are the historical, sociological and religious sensitivities. The scientific process works to balance a vast range of on-going situations of specific processes. Christie asserts that this way of learning science may provide better answers to ecological questions than does the standard Western form.

O'Hearn (1976) adopts a definition of scientific literacy that includes the social and cultural implications of science. The author states that most high school texts are deficient in this area. The author acknowledges the difficulties of inserting critical analyses of the constructive uses and the misuses of science into the curriculum. One novel solution the author offers is to choose the 'future' as an organising principle. The ingredients proposed are the future as an indigenous concern of science, the future as a social imperative, and the future as a strategy for learning. The challenge issued to all science educators is to go beyond the tried and safe teaching methods and become speculative about the future and the role of science. Scientific literacy considered as the level of cultural concern is defined as: "Literacy in science implies not only an ability to read and communicate about science, but a willingness and perhaps an eagerness to do so" in order to shape our own cultural future (O'Hearn, 1976, p. 104).

In another example of the cultural context of scientific literacy, Hirsch (1987) states that appreciation of one's cultural heritage is not complete without reference to scientific literacy within the cultural context:

> Science has been and continues to be one of the noblest achievements of mankind [sic]. From a humanistic point of view, its attainments are on a par with great achievements in art, literature, and political institutions, and in this perspective, science should come to be known for the same reasons as those of other subjects. (p. 151)

Another example of seeing scientific literacy within a cultural context is supplied by Beavis and Gough (1991). In this example, the influence of the sub-culture of teenage pop culture was seen as a way of enhancing the understanding of scientific literacy. For example, the dialogue in animated video productions of Teenage Mutant Ninja Turtles indicates that although they are portrayed as villains, deliberately modifying climatic conditions, they defy the persistent myth that changes in climate occur independently of human agency or control, and this dialogue aids discussion about environmental damage caused by humans including the 'greenhouse effect'.

> We see the development of any conception of 'scientific literacy' concerning the greenhouse effect as including examination of, for example, cultural myths of climate change and their intertextual significance. (Beavis & Gough, 1991, p. 9)

Beavis and Gough (1991) state some of the implications of their research into the ways in which the language of climate change is entering the intertextual lives of learners, for example through the songs of the pop group 'Midnight Oil':

> Such examples suggest to us a need for classroom research which explores how teachers, student teachers and children relate their readings of popular culture to their readings of curriculum materials and other information concerning the greenhouse effect and climate change. (p. 10)

Beavis and Gough (1991) are continuing their research into the value of using pop culture in classrooms in helping teachers and students assess young people's world views. The researchers believe that this approach may lead students to be more conscious and critical readers, developing analytical abilities to be used elsewhere. However, such a move also uncovers subjectivities on the part of teachers, and scientific literacy may in fact mean adopting a poststructuralist stance enabling children to turn their own discourses and practices against those world views that constrain them.

Concern within an Ethical Context

Aikenhead (1985) is concerned about scientific literacy in the ethical context, by quoting a number of examples:

> When deliberating over a controversial decision, scientific and technical knowledge is more often misused than ignored. The federal cabinet minister's decision on an abortion bill illustrates this point. Other familiar examples include: using a political argument to evaluate scientific data in a court of law; using the biological concept of natural selection as a justification for a particular socio-political ideology, 'survival of the fittest'; using Einstein's relativity theory as a justification for accepting all viewpoints of ethics; and using the prestige of technology to justify dubious social, psychological, and medical experiments (Graham, 1981). A thoughtful strategy for decision making would be to avoid such abuses of science. Abuses may arise, or go undetected, due to a lack of understanding the characteristics and limitations of science and technology. (p. 463)

Suzuki and Knudtson (1990) present the complex field of genetics in informal language suitable to lay readers. Instead of presenting readers with seemingly irreconcilable moral dilemmas arising from genetic practices and research programs, the authors propose a number of concrete moral solutions. From this standpoint they acknowledge that they embody a distinctly humanistic point of view. The role of scientific literacy then is one of coming to grips with values that are inseparable from human life. The authors set out to enable everybody to share the responsibility for the decisions that will increasingly shape the genetic future of the planet. The writers provide a good model of being scientific literate in the sense of articulating their level of concern about the impact of science on society.

An example of scientific literacy within an ethical context is given by Bybee and Najafi (1986), who cite the popularity of the courses offered in this area as an indication of the level of this concern for global problems such as air quality, world hunger, war technology and others:

> For a decade or more the scientific and technological literacy of non-science, science, and engineering majors has come from courses and programs distinctly new and different. Various science, technology, and society offerings incorporate science concepts with technological, ethical, political, and economic dimensions. In 1978, for example, there were over 900 college programs in the field of ethics and values in science and technology. Given the present national and global situations, there are now probably over 1,000. (p. 444)

This concern is supported by a similar study (Bybee & Mau 1986) in which scientists around the world were surveyed for an expression of their concern for global problems.

Paulo Freire's (Freire & Macedon, 1987) notion of literacy is that it is the means for achieving peace and human rights for all. Literacy is the quality of consciousness, not simply the mastery of morally neutral scientific techniques. Therefore, otherwise successful scientists and engineers can be scientifically and technologically illiterate if they are captured by their own conceptual tools and the impersonal demands of technical efficiency and instrumental reason.

At this point, the current literature concerning critical literacy can be introduced and applied to scientific literacy. Critical literacy can take many forms (Comber, 1992). However, four guiding principles are advocated for repositioning students to deconstruct and even resist text, according to Freebody and Luke (1990):

> A successful reader in our society needs to develop and sustain the resources to adopt four related roles: code breaker ('how do I crack this?'), text participant ('what does this mean?'), text user ('what do I do

with this here and now?'), and text analyst ('what does all this mean to me?'). (p. 7)

It is in this sense of critical literacy that scientific literacy within an ethical context may best be promoted.

Interim summary.

Scientific literacy understood as the level of concern about the impact of science is the second of three referent categories used by a number of authors. The impact of science has been interpreted within a societal, cultural or ethical context and the level of concern is regarded as the primary focus of the meaning of scientific literacy. The third referent area is that of scientific literacy being the level of language skills required for the communication of science.

Level of Language Skills for the Communication of Science

The references in this category to the meaning of scientific literacy all post-date the Pella at al. (1966) study. In this category, the term scientific literacy refers to the level of language skills in communicating science. Some referents support the meaning of scientific literacy as the level of language skills within a language register of science, while others support the use of non-formal language for the communication of science. Yet others consider the level of language skills to be judged by the use of formal English grammar conventions.

Literacy within a Language Register of Science

A simple definition of a language register is supplied by Richards, Platt and Weber (1985) as:

> A speech variety used by a particular group of people, usually sharing the same occupation (eg doctors, lawyers) or the same interests (eg stamp collectors, baseball fans). A particular register often distinguishes itself from other registers by having a number of distinctive words, by using words or phrases in a particular way (eg in tennis: deuce, love, tramlines, van), and sometimes by special grammatical constructions (eg legal language). (p. 242)

The content of one example of an actual course in scientific literacy is supplied by Ewer and Latorre (1987). It is about language constructions such as the simple present active verbs, anomalous finite verbs, past perfect conditionals, infinitives and others. It is described by Ewer and Latorre (1987) as:

> This basic language is made up of sentence patterns, structural (functional) words and non-structural vocabulary which are common to all scientific disciplines and form the essential framework upon which the social vocabulary of each discipline is superimposed. (p. ix)

Similarly, an analysis of the sub-language grammars was undertaken by Sager (1975). A computer analysis method was used to distinguish the characteristics of science text. In this way, a science field of sub-language grammars was established. The differences in sub-language grammars, for example, in specific areas such as pharmacology, from natural language text were clearly demonstrated. Conduit and Modesto (1990) undertook an investigation of the generic structure of the material/methods section of scientific reports. The investigation concentrated on one genre of scientific writing, genre being defined in the terms of Martin (1985) as "a staged goal-oriented purposeful activity in which speakers (and writers) engage as members of one culture". The results are not important here, but the assumption of Conduit and Modesto (1990) about scientific writing is interesting: "In line with science as a thing-oriented rather than a person-oriented discipline, the interpersonal function was not considered relevant" (p. 112). This indicates an assumption of competency in genre structure for scientific communication to be predominantly in field and mode rather than in the tenor of the communication.

According to Widdowson (1979), "scientific discourse is a universal mode of communicating, or universal rhetoric, which is realised by scientific text in different languages by textualisation" (p. 52). Discourse conventions are used to communicate within a common culture irrespective of the linguistic varieties. Widdowson (1979) draws the comparison between scientific discourse and non-scientific discourse. The difference is that scientific discourse has the primary culture of science as a subject and proceeds to the secondary culture (audience) by way of its genres of communication. On the other hand, non-scientific discourse such as scientific journalism begins in the secondary culture and proceeds to the primary culture of science by the journalistic genres, for example by using attitudes, beliefs, and conventional views of the world. Widdowson's (1979) view of scientific literacy is mastery of scientific discourse, analogous to the universal deep structure, mastery of texts analogous to surface variants in different languages, and mastery of textualisation analogous to transformational processes which mediate between the two.

More specific analysis of subject specific language indicates that there are usages peculiar to particular disciplines such as chemistry. For example, Schoenfeld (1985) described the use of the verbs such as 'react' as a transitive verb, which is not conventional in English language, and also the use of certain participles in 'oxidising agent', and 'oxidised substrate' in preference to the '-en' or '-t' ending of the past participle. Schoenfeld (1985) contends this is a small example of transformational grammar being intuitively constructed. Touger (1991) analysed language used in physics and gave one example to show that the inherent way of speaking of the idea of force-as-agent rather than force-as-action is misleading. Competency in language usage would preclude the use of language for force as an agent such as 'force acts', or 'forces due to gravity act' or 'the force on an object' rather than 'Earth pulls' or 'gravitational forces exerted by the object' or 'a body exerting force on an object'. Touger (1991) showed that students draw misleading inferences about the meaning of the language from the form that the language takes. Whitworth (1981) supports technical language usage and includes the use of mathematical equations within the language register of physics.

Francis and Hill (1990) distinguish some of the specific features of the language register of science as it applies to chemistry. For example understanding the meaning of scientific diagrams and the specialist use of non-technical words make certain readings specific to chemistry. The development of the language of chemistry has a distinctive history, using various symbols, representations and equations (Crosland, 1978). Knowledge of the precise meanings of concept words and process words together with their definitions was used by Lynch (1978, 1979, 1980) to measure the performance of Tasmanian students in the language of science. Competency with concept words is regarded as essential for scientific literacy.

Other researchers look more wholistically at scientific literacy within the language register of science. This is evident in the literature that expounds the use of the scientific genres of communication. Elliott and McGregor (1990) describe a number of notions of genre that have appeared in the literature: folk definitions, structural definitions, social definitions, linguistic definitions and generic motifs. It is clear that writers such as Martin, Christie and Rothery (1987) use genre in the linguistic sense of a staged, goal-oriented, social process. The philosophical position of the genre school is an interpretation of the Whorfian hypothesis that a system of language reflects a certain world view (Whorf, 1956). Thus scientific concepts are not separable from the generic forms in which they are conventionally couched. In contrast, other theorists, according to Elliott and McGregor (1990), consider that "children can and need to master concepts of scientific thought before learning the appropriate formulations for expressing them" (p. 6).

In support of competency in using the genre structure for enhancing scientific literacy, Martin (1990) makes a strong case for specific writing skills in science. Writing in science is different to writing in other parts of the curriculum. Social semiotics require provision of specific models of written science genres and this is a step in helping students with language difficulties. Martin (1990) states that:

> To rehabilitate literacy in science, teachers and students will have to work towards a much clearer grasp of the function of language as technology in building up a scientific picture of the world. Technical language has evolved in order to classify, decompose and explain. The major scientific genres: report, explanation, and experiment, have evolved to structure texts which document a scientist's world view. (p. 115)

Martin (1990) argues for explicit teaching of the scientific genres because access to these genres provides empowerment. Mastery of the genres leads to critical literacy which treats linguistics as a political form of social action (Martin, 1991). Therefore, a shift of focus from content in science to the language of science and scientific literacy, is a stepping stone to critical literacy.

The contrasting process approach to writing is condemned by Martin (1985) as reproducing the social order rather than empowering those without the inherent background of the dominant society, to challenge it. Martin deplores the use of various liberal forms of process writing such as the preoccupation with children selecting their own topics, the reluctance to intervene positively and constructively during writing, and the complete mystification of what has to be learned for children to produce effective writing products. Martin (1985) says:

> Liberalism as it is currently practised in these forms is the major enemy of children, women, working-class kids, migrants and Aboriginal children in Australian education...
>
> The sooner they control factual writing of different kinds, the sooner they will be able to understand and challenge the world in which we live. And they need to be taught to write; only a few of them can learn it on their own. (p. 61)

Teaching factual writing by genre approaches is detailed by Callaghan (1989) who describes the social function, the generic structure and the language features of each genre. Wasson (1986) describes the functions of the language rather than grammatical models, including comparing, classifying, defining, sequencing, generalising, cause and effect, reporting, predicting, hypothesising, inferring, arguments and making value judgements. The general view portrayed about scientific literacy is that it is a mastery of skills within the language register of science.

Another example of looking at the language of science wholistically is that of the Longman Dictionary of Science (Godman & Payne, 1979). Thirteen hundred basic terms that differ in meaning from common usage, and are commonly used in all branches of science, are integrated under head terms and linked by semantic net diagrams. The subsumed terms within the head term have specific meanings in science and can be further categorised for each science discipline.

It is within the context of communicating science in a special language register that the Secondary Board of South Australia describes scientific literacy. The physics Stage 1 Extended Subject Framework (Senior Secondary Board of South Australia, 1991) requires students to "develop their scientific literacy and in particular their use of the terminology and notation" (p. 5). The pursuit of this form of scientific literacy is set as one of objectives within the domain of communicating knowledge of physics.

Literacy within Non-formal Science Language

Scientific literacy for Lemke (1982) is the shared use of language in general. Scientific literacy is about the quality of the oral discourse in science in which thematic patterns are established regardless of the amount of formal language register of science used. Lemke (1982) explains that:

> The effective language of the classroom is the shared language of pupils and teachers, a constantly changing hybrid of common parlance, our ordinary ways of talking, with the registers which teachers and pupils may use in other settings. (p. 264)

The patterns of classroom discourse were analysed by Lemke in a number of studies (1982, 1985, 1990) and these patterns indicated that strict adherence to the stylistic norms of science language inhibited the development of thematic patterns in students' understanding of science. Lemke (1990) advocated a process of norm-violation in the talking in science. Some of the stylistic norms such as avoiding colloquial forms, avoiding personifications, avoiding metaphoric and figurative language, avoiding reference to personalities, fiction and fantasy could be violated in the pursuit of humanising science and communicating it. The so called mystique of science needs to be deflated so that it is not made alien to students' experience. From research findings, Lemke (1982b) states that "talking physics at pupils does not usually produce immediate changes in their ability to talk physics with us" (p. 264).

Lemke's (1990) view is that science is but one way of talking about familiar and unfamiliar experiences in order to relate them to each other. "It does not require any special talents or above-average intelligence to learn this way of talking" (p. 176).

The use of the narrative genre is seen as a way that the language skills of communication of science within an informal language can be developed. Strube (1985) researched the historical evolvement of the science text book and contrasts the present situation with the large amount of narrative used previously. Narrative allowed the reporting of conversations about the value of science and its integration into the cultural setting as well as extending knowledge. Strube (1989) argues for the role of imagination to be used in becoming scientifically literate:

> If the student as either reader or writer, experiences the components of the scientist's world as characters treated imaginatively, he or she can come to see them as possibilities for further thought and action. (p. 53)

Trigg (1993) explored the use of poetry as a means of providing a rhythm in science similar to the characterises of much poetry. For example:

Bernoulli bernoulli
thinker of theorems
about moving molecules
of fluid flowing
through tubes

How does each
molecule know when
to swirl sedately
through a wide
pipe and spurt
speedily through the thin?

Don't moving molecules
have manners
to wait graciously
in line?

alas to find
according to Mr
Bernoulli,
the little devils
push and pull
just like people
swirling along platforms
and squeezing in
trains

(Permission given by Ruth Trigg, 27.4.94, for inclusion here)

This poem ignores the conventions of the scientific register, and even conventions of grammar, for example, punctuation. However, it provides an almost experiential sense of rhythm in its reading and recitation. In this manner it successfully conveys an experience of moving molecules and allows prediction of the effects of those molecules in contrast to conventional scientific writing such as:

> Bernoulli's Theorem: that the sum of the pressure, potential and kinetic energies per unit volume is consistent at any point in a tube through which liquid is flowing, pressure being the smallest at the point of greater velocity. (Trigg, 1993)

In support of the use of poetry within the language of science, Trigg (1993) cites a quotation from Weschler (1988) as follows:

> Niels Bohr, recalled Heisenberg, equates the language of poetry and physics...when it comes to atoms, language can be used only as in poetry. The poet too is not nearly so concerned with developing facts as with creating images and establishing mental connections...Quantum theory provides us with a striking illustration of the fact that we can fully understand a connection though we can only speak of it in images and parables. (p. 4)

Development of scientific literacy within the general language acquisition supports the use of a non-formal language for enhancing scientific literacy. The theories of language and thought can be roughly divided into behaviourist, nativist and interactionist theories. The behaviourist theories would have language acquisition taking place through operant conditioning (Skinner, 1957) in which shaping, reinforcement and selective reinforcement takes place. This theory failed to explain the speed at which learning of language took place. In contrast, the nativist theory of Chomsky (1965) would have that human beings are programmed to acquire language. The in-built device, called a Language Acquisition Device, was a set of cognitive and perceptual abilities that were specially sensitised to the structured properties of language. This theory failed to answer the question as to whether thought structured language or language structured thought. Piaget (Ginsburg & Opper, 1969) adhered to the former construct, while Vygotsky (1986) and Bruner (Bruner, Goodnow & Austin, 1956) adopted a view that language itself structured thought. Bruner used 'scaffolding' as a language acquisition device, while Vygotsky proposed a 'zone of proximal development' in which assistance of a mature thinker would greatly enhance unaided learning. Scientific literacy therefore could be seen as part of general language acquisition according to these theories.

Literacy within Formal English Grammar

Reading and writing are taken as the general literacy skills and are sometimes referred to as the macro literacy skills (Richards et al., 1985). Functional literacy is described as a person's ability to read and write sufficiently well to meet the social purposes required in normal adult life. Scientific literacy therefore would merely be reading and writing science at this functional level. Within this context remedial attention has been given to reading and writing in science. Lavoie and Backus (1990) investigated the problems that students often had with writing, and identified a number of impediments to writing such as misconceptions, lacking conceptual frames, self-awareness, self-connection, self expression, and an inability to respond to a world view. The authors proposed certain writing techniques to overcome these impediments. They took 17% of class and laboratory time to present and develop writing tools, and despite the significant decrease in time available for content presentation, the average final grade increased by 10% compared with grades from the period without development of the special writing techniques. Lavoie and Backus (1990) concluded from the test data that "writing shows hierarchical characteristics that match up well with the hierarchical structure of learning" (p. 353).

Morris (1987) found that using a structured overview during the reading process was an effective technique for children. Construction of a structured overview concept map enabled learners to see the overall picture and then to make connections with existing knowledge. It was, in effect, using an advance organiser during the reading activity and was particularly effective with the non-narrative genres. Young, Ruck and Crocker (1991) showed that reading in science required a different range of skills from narrative and fiction literature, such as predicting the sequence of events, and in contrast, empathising with characters would not necessarily help with the understanding of magnetism or electricity. The remedial step proposed was to use reading-strategy questions such as "ask question(s) that students respond to by explaining how they determine, or could determine an answer" (p. 48) rather than the answer itself. In this way the awareness of text structure is developed.

Gardner (1974, 1975, 1976, 1977, 1978, 1980) researched the problems of language difficulties in writing experienced by science students. One aspect of the difficulty was the neglect of explicit teaching of non-technical language used in science texts. The technical language of science was apparently an object of explicit teaching by most teachers. However, there was neglect of the non-technical aspects. The analysis of logico-grammatical structures at a deeper level than vocabulary found these structures to be the cause of many problems to the science student. For example, illative terms (consequently, hence, thereby, therefore, thus), were used with significantly greater frequency in science texts than in all other texts. To improve literacy in the science area, the author suggests remedies based on explicit teaching of the non-formal science language. This is supported by the research of Cassels and Johnstone (1984) who found that the words which gave the most trouble were not the technical words, but those used in normal English but which had a specific meaning in science. They found that minimal altering of non-technical words in science examinations produced large changes in consequent results.

The structure of English usage in science was analysed by Halliday (1990). Scientific discourse was difficult to understand because of seven interrelated linguistic characteristics: lexical density, grammatical metaphor, semantic discontinuity, syntactic ambiguity, special expressions, taxonomies and definitions. It is clear that this analysis is a linguistic analysis, treating science as text for reading and writing for functional literacy. Halliday (1990) agrees that science requires a certain amount of complexity and difficulty, but is critical of over complication, "marking it off as the discourse of an intellectual elite " (p. 15), and criticises those who "not being scientific, have borrowed the trappings of scientific language and are using it as a language of prestige and power" (p. 34).

Chapter Summary

This review of literature although not exhaustive, provides the main areas in which the term scientific literacy has been applied. The review has categorised the references into three referent areas: the level of science knowledge and understanding, the level of concern about the impact of science, and the level of language skills used to communicate science. The three referent areas are obviously linked and overlap each other. However, the focus and emphasis in each referent area serves to highlight different meanings for the term scientific literacy.

Each of the referent areas of the term scientific literacy was divided further into sub-categories of the meaning of scientific literacy. The task for this research was to formulate a comprehensive definition of the term. The difficulties were as follows:

* Is it possible or even desirable to integrate all aspects of the meanings used in literature for scientific literacy?

* Is scientific literacy about gaining more science knowledge for everybody or is it about contextualising science even at the expense of content knowledge?

* Is scientific literacy the pursuit of objective methods in science or is it the pursuit of subjective interpretations in order to preserve the societal, cultural and ethical values?

* Should the enhancement of scientific literacy lie in greater instruction in the language register of science or should it be in the form of general language acquisition?

It would be difficult from this literature review to formulate a consensus definition for the term scientific literacy. There seems to be a need to examine a number of theories from which many of the above references seem to be drawn. Aspects of cognitive theories, linguistic theories and the philosophical notions about science need to be examined to formulate some coherent statement that will integrate these aspects. These theories are discussed in Chapter 3 and the outcome of this examination is the proposal of a comprehensive definition that encompasses many of the referent positions adopted in the review of literature in this chapter.

CHAPTER 3
SCIENTIFIC LITERACY: A THEORETICAL FRAMEWORK

Introduction

The first purpose of this study, as outlined in Chapter 1, is to propose a definition of scientific literacy that will generate a new model for the development of scientific writing for upper secondary students. In the previous chapter, scientific literacy was described in terms of attainment levels within a number of referent areas identified in the literature. Attainment levels were described as levels of science knowledge and understanding, or the levels of concern expressed about the impact of science on society, or the levels of language skills required in the communication of science. This research project proposes to avoid such static definitions by defining scientific literacy in the form of verb phrases. Certain human activities, such as dance or dream, can be defined as verbs as well as nouns; so also can literacy be defined, although literacy as such does not exist a verb in the English language lexicon. The definition proposed here is based on the belief that scientific literacy can be defined in verb phrases relating to the functions of being human. Rather than a measurement of levels of attainment, the definition can be a dynamic one about what activities are taking place at the subconscious level of the human affective and cognitive domain. Scientific literacy is described here as an activating function within the cognitive domain, and is supported by the theoretical framework outlined in this chapter.

The fundamental process of literacy as a verb means activating the human cognitive domain before expression in the linguistic domain can be achieved. Therefore the proposed definition for scientific literacy is:

> Scientific literacy is the human function of activating the cognitive processes in the discourse of science and communicating this discourse in a form of language register of science.

To define cognitive processes, two broad theories of cognition, the Classicist and the Connectionist theories, are discussed in section two of this chapter. To define the discourse of science, the theories about scientific realism are discussed in section three. Communication in a language register of science, and for Australian students, within the English language conventions, is discussed in section four of this chapter. The development of this definition is based on this reconstruction of a theoretical framework rather than on the descriptions of conventional practices that emerged from the literature analysed in Chapter 2.

From this theoretical framework it is possible to generate a new model for scientific writing for upper secondary students distinct from existing models of writing, which are described in the fifth section of this chapter. The proposed model for scientific writing in the explanation genre is called here a 'HyperCard Pathways Writing Model' (HCP) and is described in the sixth section. The development of a classroom program for implementing the HCP writing model is described in Chapter 5.

Defining Cognitive Processes

West, Fensham and Garrard (1985) suggested that cognitive structure "is extensive and n-dimensional. Any attempt at description can only hope to illuminate part of the whole" (p. 33). Their description lies somewhere between the associative network descriptions (Lindsay & Norman, 1977) and concept mapping ideas from such writers as Ausubel (1968), Novak (1980), and Novak and Gowin (1984). Cognitive structure according to Novak (1977) "represents a framework of hierarchically organised concepts, which are the individual's representations of sensory experience" (p. 25).

White (1985) similarly defined cognitive structure as the knowledge someone possesses and the manner in which it is arranged, and although the units might be problematic, agreed that a representational structure must include propositional links but may also include algorithms, images and episodes. Most researchers do not attempt to make a holistic definition of cognitive structure. They undertake to describe one or more aspects of it, or describe results of tests on certain aspects. The common feature that emerges from various investigative techniques is that there is some form of representational structure.

However, the model of representational structure depends on the view held concerning cognitive theory. In one view, according to the Classicist model, the cognitive processes are a symbols-system, manipulated by inherent syntactical rules independent of the medium, similar to the way machine language has been developed into artificial intelligence. The other general view, called a Connectionist model, is medium dependent and states that cognitive processes are based on neural networks, similar to electronic networks as in the case of intelligent machines. These two general views are discussed in this section.

Defining Cognitive Processes within Two Cognitive Theories

Cognitive science is a new discipline incorporating theories from other disciplines. According to Anderson (1990), the beginning of this field can be dated from the appearance of the journal Cognitive Science in 1976. It is the integration of psychology, philosophy, linguistics, neuroscience and studies in artificial intelligence. The overlap between cognitive science and cognitive psychology is broad, and distinctions cannot be defined precisely. Anderson (1990) describes some differences in methods saying that:

> Cognitive science makes greater use of methods such as computer simulation of cognitive processes and logical analysis, while cognitive psychology relies heavily on experimental techniques that grew out of the behaviorist era for studying behavior. (p. 10)

Anderson (1990) recognises the contribution of linguistics to the theories of cognition. The linguistic analysis of Chomsky (Smith & Wilson, 1986) is regarded as being critical to cognitive psychology in the movement away from behaviourist approaches. The theories of cognitive science attempt to explain the inner activation of cognitive processes, hence they are integral to discussion of an activating scientific literacy.

Classicist Models

The composition of symbol-systems and the activating manipulations through intrinsic rules of syntax, are regarded as computational processes in the Classicist model. The computational theories of thinking originated with Hobbes (Haugeland, 1990) in the seventeenth century with the belief that symbol manipulations are the basis of thinking.

Fodor (1987), a proponent of the Classicist model, regards the language of thought as an innately determined species-specific code that is quite distinct from any acquired natural language. Such an innately determined language of thought can thus be invoked to explain the cognitive performance of some people in non-verbal activities. This notion of the language of thought is regarded as a formal system, that is, all the semantic properties of mental representations are mirrored by syntactic properties. Two mental symbols or representations will differ in their semantic content if and only if they differ in their syntactic structure. For example, the presence of lexical ambiguities means that there are times when syntactically identical expressions have different semantic contents.

The language of thought of Fodor (1987) is similar to Chomsky's proposal (Chomsky, 1957) in linguistics, that an innate grammar can generate new grammars and transform current grammars such as active and passive voice sentence structures. This linguistic theory provides a matching point between activating literacy and the Classicist view of computational theory. The innate grammar theory rests on the observation that children exposed to a limited number of sentences acquire the capacity to produce an infinite number of new grammatical sentences. This can be explained in literacy terms as the capacity for an infinite number of causal relationships to be made between mental states. Similarly, innate grammar can be explained in computational terms as the capacity for the syntactic engines to produce an infinite number of semantically coherent outputs.

It was not possible to simulate a language of thought process in a machine until Newell, Shaw and Simon (Haugeland, 1990) in 1955 produced a "thinking program" (p. 176), which differed from the earlier work on cybernetics because of its focus on thinking itself rather than on a translating process. Further developments in machine language occurred through programs such as "LISP" developed by McCarthy in 1959 (Davidson, 1993) and ELIZA (Weizenbaum, 1966). It would seem that the human cognitive processes can be similarly activated, given that the techniques for developing scientific literacy address the components of representational structure, propositional links and conceptual relationships.

Connectionist Models

In contrast to the Classicist view, the analogue computational theory holds that a neural networks approach is more productive. It holds that thoughts are medium dependent. This gives rise to Connectionist models of thinking such as the Parallel Distributed Processing or PDP model (Rumelhart & McClelland, 1986). This form of computation is a bottom-up approach, that is, from cell-to-cell processes in the medium. For human cognition, the brain is the medium and for machines, electronic and opto-electronic components are the medium. The medium is regarded as the neural network which processes information, not because it is programed according to rules of syntax, but because the neural networks learn to solve problems after specified training.

Relaxation search processes are the creation of successive activation patterns proceeding back and forth in the hidden units of PDP before settling into a new and stable activation pattern of best fit. There is a constraint processing device that allows the new pattern to find best fit within the hidden units before emerging at the output units. The training procedure for such a network training is described by Hinton and Sejnowski (in Wasserman, 1989).

Pattern-making processes for feed-forward networks take place through learning rules such as back propagation and others. In the back propagation process, both the current network pattern and the desired target pattern are identified; then connection weights are calculated and adjusted accordingly. Training of neural networks has been successively achieved such as the neural network NETTALK which converts printed English text into highly intelligible speech (Wasserman, 1989).

A comparison of Classicist and Connectionist theories about activating the cognitive processes for scientific literacy can be discussed under the terms of representational architecture, language of thought, and learning mechanism.

Comparing the Models

Representational architecture. Fodor and Pylyshyn (1988) claim that Classicism is a superior theory. They reduce Connectionist theories of neural networks and spreading activation patterns to a subset of processes within symbol representational states. Fodor and Pylyshyn (1988) claim that this form of representation is just an implementation of symbol manipulations, reinforcing their own allegiance to Classicist theory.

Not surprisingly this is challenged by a number of Connectionist adherents. Chater and Oaksford (1990) challenge the implementation notion saying that it underrates the ability of Connectionism to explain the higher level notions of cognition. Chater and Oaksford (1990) then examine eight so called "lures" (Fodor & Pylyshyn, 1988) of Connectionism and find that some of them apply equally to Classicism, such as macroscopic non-determinism of human behaviour. Other lures seem to be more peripheral than substantial. Another refutation is that credit is not given by Fodor and Pylyshyn to the Connectionist explanation of non-verbal and intuitive processing, which can either be stored at the recreated patterns in recurrent or feed-forward networks.

Contrary to the claim of Fodor and Pylyshyn (1988), representation is addressed by Connectionism at a higher level. For example, vector representation in multi-dimensional space is a possible representation, as shown by Churchland (1992). Simulation vectors are a possible form of Connectionist representation, as described in Wasserman (1989).

The evidence for this was first seen in the construction of WISARD, the first large scale neural network for commercial use created by Aleksander and others in 1982 (Davidson, 1993). One application of this was a machine that recognised human faces after only 20 seconds of training; another application was a machine that recognised bank notes at high speed; a third application a machine that picked out defective components in a factory assembly line. It is possible for machines to utilise electro-optical multipliers which provide speed times potentially in the sub-nanosecond speed range. The use of photons rather than electrons allows for representation either in thin wafer or volume holograms which can be retrieved rapidly and reliably (Wasserman, 1989). Similarly, it can be proposed that scientific literacy is dependent upon a pattern-recognition network according to the model of McClelland and Rumalhart (1981). It would mean that scientific literacy is best implemented by an interactive technique such as the one proposed later in this chapter.

Language of thought. The "language of thought" (Fodor, 1989, p. 23) under Classicism explains propositional links as relational symbol tokens. Classicism holds that mental states and not just their propositional objects have constituent structure. Three arguments are then given by Fodor for mental states having constituent structure including the argument of systematicity of thought. The 'John loves the girl' example is used to show how neural networks even if designed to represent the nouns 'John' and 'girl' and 'loving' as nodes, are not readily adapted to the converse thought (the girl loves John) as is the case with combinatorial semantics and syntax through symbol manipulation. Symbol manipulation, in contrast to neural activation, allows for rapid changes of syntax to preserve the semantic meanings. This is regarded as the systematicity of thought argument.

The reply by Smolensky (1989) for Connectionism, is that activation in neural networks takes place intrinsically at two levels:

> The semantic interpretations are at the level of activation patterns and that mental processing is carried out at the level of individual activity values and connection weights (p. 22).

This means that activation spreads from the medium to excitation of letters and from letters to the excitation of words. The connection weights adjust according to pattern recognition. Although this explanation is not regarded as a convincing reply to the systematicity of thought argument, the Connectionists think that further development will provide answers, for example in the pattern-recognition experiments of Treisman and Gelade (1980).

Learning mechanisms. Another Connectionist difficulty is that the explanation of learning is not adequate. The Classicist explanation is more plausible, because in the generation of new concepts, the computational processes as token manipulations are explained by tokens and syntactical propositions which seem to follow rules for semantic coherence. Connectionism needs to explain how a system that essentially grows no new connections can recruit compact groups of units to capture new concepts and relations. One possible explanation is that neural networks locate random clusters that activate new patterns in the first instance (Smolensky, 1989).

Instead of joining the debate as to which theory best explains human cognition, some authors have investigated a hybridisation of the two models. Hendler (1989) gives one example of the success of this hybrid model with encodings of sentences that contain two different meanings for the word 'throw': 'John threw the ball' and

'John threw the fight'. A table of connectivity weights derived after a training period is transferred to a local Connectionist simulator, which distinguishes positive activation at the node 'throw' meaning propel and negative activation at the node 'throw' meaning surrender, and alternatively for the second intended meaning.

An integrated model using both neural architecture and a symbols manipulation program was the basis for the construction of a hybridised model called 'SOAR' (Rosenbloom, 1989). It was designed to integrate basic mechanisms for problem solving, learning, and perceptual-motor behaviour. The development is in its infancy, but it lends support to the idea that activating the human cognitive processes may be possible through both Classicist and Connectionist techniques.

Applications of Cognitive Processes Theory

The applications of cognitive processes theory can be seen in the use of representational structures that are multi-dimensional, with propositional links bound together by conceptual relationships. The usefulness of these applications of cognitive processes are described as follows by White (1985):

> Their popularity in models of cognitive structure is explained: they are the basis of writing and speaking; they are a conveniently sized unit; their possession is readily tested; and it is easy to devise instruction to give people blocks of propositions sensibly collected together. (p. 52)

These applications of cognitive structure are described in the following paragraphs.

Representations. Some of the research techniques into cognitive structure involve students in producing semantic nets, tree diagrams, rotated two dimensional matrices, and concept maps. Semantic nets show the spatial representations of relationships between concepts, and hence this is a feature of the cognitive structure. According to Anderson (1990), "the propositions, the relations, and their arguments are called the 'nodes' of the network and the arrows are called 'links' because they connect the nodes" (p. 126). The relations are defined according to type, for example, actor, instrument, location, object (Norman & Rumalhart, 1975). Fisher, Faletti, Patterson, Thornton, Lipson and Spring (1990) developed a computer-assisted program to assist in the creation of semantic networks. The emphasis in this program is on making the relationship between concepts explicit by the use of uni-directional or bi-directional arrows and precise definitions.

The method of construction of tree diagrams was devised by Rapoport (1967) for measuring semantic difference between concepts. Most related concepts were linked and numbered, to indicate the notion of precedence. The emphasis is on relatedness between concepts rather than the precise definitions. The rotated two dimensional matrix representation was used by Champagne, Gunstone and Klopfer (1985) to measure the changing patterns of cognitive structure before and after instruction. The matrix is constructed by word association values and 'goodness-of-fit' statistics applied to the resultant matrix.

Concept maps have been used extensively by Novak (1977) and Novak and Gowin (1984). This is an hierarchical arrangement of concepts. The essential features are hierarchical levels of concepts, links and cross links for relatedness, clustering of subordinate concepts, and propositional statements of relationships between concepts.

Propositional links. The propositional links may be in the form of syntactically linked symbol-systems to provide internal meaning. For example, White (1985) states that:

> The essential feature of the distinction (between propositional and algorithmic knowledge) is that where propositions are single facts, intellectual skills are rules which direct behaviour so that people can perform whole classes of tasks. (p. 53)

Alternatively, the propositional links may result from activation patterns in neural network according to the Connectionist model as described by Rumelhart and McClelland (1986). However, such properties as hierarchical ordering, differentiation and clustering can be illustrated on concept maps, regardless of the instantiating structure. These properties are indicative of the forms of human cognitive processes and are used in the development techniques of scientific literacy discussed later.

West et al. (1985) investigated the cognitive processes of eleventh grade high school students. This resulted in a variety of representations that indicated the highly idiosyncratic nature of cognitive structure. They were able to show that meaningful learning is achieved, according to Ausubel's theory (1968), when propositional links are extended through processes of assimilation and differentiation.

Conceptual relationships. The definition of cognitive structure according Pines (1985) is similar to that of West et al. (1985), in that it consists of units of knowledge, ideas, meanings, concepts and cognitions, structured in some manner of arrangement, and in addition, there is the importance of the binding relations within the structure. Pines (1985) states:

> What binds them together are relations. Meaning, thought, concepts and language depend on relations. So too does their structure. (p. 101).

These bonds are called conceptual relations. Concepts are packages of meaning based on language representation. Other forms of representation are sign and symbol, which are the subject matter of the wider study of semiotics which would hold that conceptualisation is facilitated by the acquisition and use of symbolic relations, especially in pre-linguistic conceptualisations. Scientific literacy includes the use of sign and symbol in the semiotic sense which is discussed in a later section. The discussion here is about conceptual relationships in the linguistic sense.

Pines (1985) refers to two fundamental types of conceptual relations: first, the set/element relationships that underlie classification systems and hence definitions; and second, the whole/part relationships which are developed in scientific writing for causal, sequential, and descriptive relationships. They are discussed in a later section dealing with models of cognitive writing. In a note of warning, Pines (1985) indicates that there are non-verbal frameworks that have no sign counterpart in the real world and may lead to science fiction but they are often the springboard of scientific creativity. Development in scientific literacy must include the non-verbal frameworks within the development of representational structure.

An Interim Summary

The above examples of applying cognitive processes theory all have inherent deficiencies in converting what is essentially a dynamic process of thinking into static models. Nevertheless, some of the strategies for applying theories of cognitive processes can be useful in the activating function required for scientific literacy under the proposed definition. The strategies that can be applied in scientific literacy are concept mapping, propositional links and the formation of conceptual relationships.

In concluding the discussion about cognitive theories, it is clear that cognitive processes are integral to activating literacy because they provide an explanation of mental representation, language of thought, and learning mechanisms. Therefore the definition of scientific literacy requires the notion of cognitive processes being employed in the ways just described. Because there is no definite solution to the cognitive theory debate, the pedagogical practices for literacy need to be equally valid for both Classicist models and Connectionist models of human cognitive processes.

The cognitive processes for scientific literacy are activated by the discourse concerning scientific realism, through mental representations, language of thought and meaningful learning. A discussion of scientific realism enables the next part of the definition of scientific literacy to be formulated.

Defining the Discourse of Science

To begin the discussion about discourse in science, the term 'discourse' is taken in its broadest meaning: the post-structuralist and semiotic meaning. Discourse here is not just simply classroom discourse such as the language and turn-taking interactions analysed by classroom researchers; it is the social process of making and producing sense. A semiotic definition is supplied by O'Sullivan, Hartley, Saunders and Fiske, (1990):

> In its established usages, discourse [refers] both to the interactive process and the end result of thought and communication. Discourse is the social process of making and producing sense. (p. 73)

The post-structuralist notion represents a group of theories that include a challenge to structured society such that fragmentation, contradiction and discontinuity are promoted for the purpose of undermining privileged positions. This is applied to discipline discourses by such means as the method of uncovering the 'archaeology of knowledge', postulated by Foucault (Rabinow, 1984), which exposes the relationship between knowledge and power. In the extreme versions of post-structuralism, even personal identity is constructed by various discourse practices and inherited positions: discourse is not created by humans, but human identity is created by discourse.

The application of post-structuralism to discourse analysis is one of deconstruction of text. It challenges the notion that text can be sites of predetermined, stable meanings. The post-structuralist approach is to "re-read the stories of our culture and to de-stabilise and de-naturalise the assumptions upon which they have relied" (Gilbert, 1991, p. 98).

Lemke (1990) views current science education as contributing to the hegemony of power through knowledge by creating a technological elite:

> The mystique of science is an essential tool for technocratic rule. Through it we are all taught that science, as the paradigm of all expert knowledge, has an objective, superior, and special truth that only the super intelligent few can understand. Science education, like it or not, does a great job of foisting these myths on us. (p. 149)

The continuing purpose of this chapter is to define scientific literacy in such a way that science is accessible to all and not confined to producing an elite. The deconstructive question about the discourse of science is raised by Lemke (1990):

> Whose interests does it serve to maintain that science provides absolute, objective truths whose proofs are accessible only to experts who are much smarter than the average person? (p. 148)

In attempting to answer this question the social processes of science are discussed in the following paragraphs according to the 'rationalist' versus 'relativist' debate.

The Social Processes in the Discourse of Science

In the semiotic interpretation, discourse refers both to the interactive process and the end product of thought and communication and is seen as the product of social, historical and institutional formation. The meaning of language is constructed within certain institutionalised discourses as described by O'Sullivan et al. (1990):

> Once the general theoretical notion of discourse has been achieved, attention turns to specific discourses in which established sense is encountered and contested. These range from media discourses like

> television and news, to institutionalised discourses like medicine, literature and science. Thus discourses are power relations. It follows that much of the social sense-making we're subjected to — in the media, at school, in conversation — is the working through of ideological struggle between different discourses. (p. 74)

The history of the development of science is suited to the methods of uncovering the archaeology of knowledge. Although the discourse of science has never been limited to one culture, one dialect of English, or one style of communication, it has been seen as special. It has become imbued with mystique, a mystique of total objectivity and according to Lemke, (1990) "the facts of science are presented as established, permanent, incontrovertible" (p. 137). Lemke suggests "that students are taught, often very subtly, that science is opposed to common sense, that it is a special truth available only to experts and mainly incomprehensible to lay (people)" (p. 138).

The need then for activating scientific literacy, is to open up the discourse to students. They need to be able to enter the range of discourse from a relativist position to a realist position, and to learn to identify these positions within the scientific discourse. This involves the use of constructive dialogue, colloquial expressions, discussion of values, the deconstruction of text, and questioning whose real interests are at stake. These are some methods that have been employed by Lemke (1990). For example the hegemony of the scientific discourse is described by Lemke (1990) as follows:

> It is not surprising that those who succeed in science tend to be like those who define the 'appropriate' way to talk science: male rather than female, white rather than black, middle and upper middle class, native English speakers, standard dialect speakers, committed to the values of North European middle class culture (emotional control, orderliness, rationalism, achievement, punctuality, social hierarchy etc.). No one points out that science has been done very effectively by other sorts of people in other kinds of cultures, or that science might look a little different in its models and emphases if its recent history had come at a time when other cultures had been politically dominant in the world and in a position to command more of its resources (say Italy, or China, or India). (p. 138)

In the proposed definition, scientific literacy is viewed as activating the cognitive processes in the various forms of the discourse of science. The recognition of the distinctive genres, thematic formations and specialised modes of reasoning are addressed in a later discussion about the language register of science. The purpose now is to explore the discourse of science according to rationalist and relativist perspectives in regard to notions of scientific realism, central to the purpose of science.

The Discourse of Rational Approaches

Traditionally it is held that rational scientific endeavour uses all of the rational methods available. These might be mathematics, the principle of purposiveness, sequencing of models, inductive and deductive reasoning, empirical testing, falsification, negative and positive heuristics, and constructive empiricism. From these methods it is believed that progress in science has taken place, sometimes in a spectacular manner, such as Halley's prediction of the return of the comet in 1682, the prediction of the elements of matter by Mendeleev for the Periodic Table in 1868, and the prediction and subsequent observation of 'big-bang' microwave fluctuations by means of the Cosmic Background Explorer satellite in 1992. One strand of literature, as reviewed in Chapter 2, presents science as a rational process and claims that the so called scientific method is the process of finding what is real, and what physical objects exist independently of being perceived, claiming that this process is the real object of scientific literacy.

However, there are problems with the rationalist science discourse. First, rationalists cannot agree about what is real. There are serious divisions between, for example, the Van Fraassen (1980) view of constructive empiricism in which empirical adequacy is the only prerequisite for reality, and the realist position of Newton-Smith (1981) in which causal realism is an adequate explanation even if underlying theories have changed. An example cited is that the electron is real today even though J. J. Thomson's term was understood differently, because it is detected in the same way.

A second problem is the inability of quantum mechanics to solve the problem of duality of particles/waves in the measurement of the wave packet collapse (Polkinghorne, 1984). The four current solutions are all found to be wanting by rational standards. For example, the following solutions are not rational solutions: the fact that physical effects must be taken as continuously progressive; action at a distance is faster than the speed of light; collapse of the wave-packet is caused by observation; probabilities replace causal factors. The acceptance of instrumentalist interpretations such as the Copenhagen interpretation of the quantum are not rational solutions.

A third problem for the rationalists is the reliability of the laws of physics. There is argument that the laws apply to elements that are incommensurable. The 'mass' of Newton can hardly be the same 'mass' of Einstein. Also the laws of physics apply only to ideal situations, such as massless points, frictionless planes, etc. The laws of physics do not take into account the chaos of the universe and merely reflect the mechanical concept of the universe. Nancy Cartwright (1983) exclaims: "How the laws of physics lie!" Indeed Newton's laws of motion with the requirement for fixed time rather than relative time, cannot be universally applicable.

So the discourse of science is problematic, although it is often presented in school texts and classroom discourse as established, permanent, and incontrovertible. Implementation of activating scientific literacy must allow for critical analysis at the appropriate level, in this case, that of secondary school science students. Martin, Wignell, Eggins and Rothery (1987) make a case for critical social literacy which aims at giving access to, and conscious control over disciplinary discourse. Science textbooks are reported by Luke (1991) to be socio-political constructions of the 'natural' world: "They collude in a transmission model of passive engagement with discourse" (p. 91) rather than being free of ideological positions.

The Discourse of Relativist Approaches

Some sociologists contend there are a number of reasons why the discourse of science is not the rational process described above: the underdetermination of theory by data, theory-ladenness of observation, analyses of science in terms of vested interest, and the actual historical record of the development of science are some examples of non-rational processes. The relativist perspective on the discourse of science leads adherents to favour either the 'weak' program or the 'strong' program in the sociology of scientific knowledge, described in the following paragraphs.

Advocates of the 'strong' program argue that the actual content of scientific theories is socially orchestrated while the 'weak' position is about the favoured interpretation of theories. A supporter of the strong version of the sociology of scientific knowledge is Latour (Riggs, 1992), who believes that what are called scientific facts are not really 'discovered' but are socially constructed and arise as a result of complex social issues. Latour's 'constructivist' view of science is that "nature is not what exists but what results when a controversy in science is settled" (Riggs, 1992, p. 161).

Riggs (1992) sums up Latour's position as a description of science being more appropriately applied to the workings of a criminal court jury, in which the competing lawyers seek to convince the jurors with court room tactics until the numbers favour either one side or the other.

The underdetermination of theory by data is described by Riggs (1992) as the problem that empirical data are of little or no assistance in singling out one theory above others for further research. The researcher must rely on some non-empirical reason to choose between competing theories. Another factor might be the specifics of funding allocations. An example of scientists being wrong because of the underdetermination of theory by data was the choice made by geologists the 1920s for 'permanentism' over Wegener's continental drift theory (Riggs, 1992).

The theory-ladenness of observation means that there cannot be a clear-cut distinction between fact and theory. There are always some preconceptions that colour empirical observations and are described as either soft or hard versions of observation. In the soft version, it is the interpretations of observations that are different. Alternatively, the hard version would have that people see different things, maybe through something like a Gestalt switch. The famous Lavoisier-Priestley debate is quoted (Riggs, 1992) as an example of the weak version, while the Pouchet-Pasteur debate is quoted as an example of the hard version: both actually saw different things about microbe generation. Pasteur had more resources and better demonstrations and hence more recognition than Pouchet and hence microbial science was 'invented', according to the claim of relativists. However, this claim seems to be unreasonable in that, had

Pouchet won the battle for recognition and resources, it is unlikely that his theories would have survived, as was the case with Lysenko's agricultural program which had political favour for decades, but which was found wanting with the eventual failure of the Russian wheat crops.

The relativists' argument that the history of science shows a socially determined science knowledge is expressed by Feyerabend (1975), who argued that the history of science indicates that unchanging rules for the conduct of science do not exist and that instead, the only real methodological rule for science is 'anything goes' (cited in Riggs, 1992). Feyerabend, according to Riggs (1992), is short of examples to support this extreme claim. Riggs (1992) argues that it is generally accepted that scientists make both conscious and unconscious mistakes like other people, being human and subject to desire for fame, funding, success and rewards, but that is a world away from claiming that 'correspondence-to-truth' in scientific knowledge is created by such effects.

Defining scientific literacy within a socio-semiotically determined discourse of science means acknowledging the debate between rationalists and relativists, and that through the use of historical perspectives, the presentation of alternative theories and deconstruction of text, it is possible to make science real to ourselves. However, the question about what is scientifically real remains.

Scientific Realism in the Discourse of Science

Scientific realism is a term that has multiple shades of meaning within the philosophical debate about science. When the Greek ideal of unified rational theory was taken up in the Renaissance, it was still understood to be a search for knowledge even though in an anthropocentric way. 'Scientia' had the same connotations of wisdom as well as the limited sense of empirical knowledge that Western science now has (Hesse, 1988). Realism, in its classical form, is understood to mean the existence of an external world and its ontology. A definition is supplied by van Fraassen (1980) as:

Scientific realism is the position that scientific theory construction aims to give us a literally true story of what the world is like and the acceptance of a scientific theory involves the belief that it is true (p. 9).

At the epistemological level, the discussion is about the nature of science rather than the nature of being, and the laws of nature are to be found by the empirical scientific method. The laws found are said to be objective truth, as explained by Chalmers (1990):

True theories if they are indeed true, are not relative to the beliefs of individuals or groups. Truth, understood as a correct characterisation of reality, is objective truth for realists such as Popper. (p. 147)

This view of science is referred to as the standard view of science and is the underlying tenet of many secondary school science programs. However, there are problems with realist aspects of the standard view which are briefly summarised here.

Problems with the Realist Aspects

Realism breaks down because of the difficulty with what is called correspondence theory, whereby scientific statements are true if they correspond in a one-to-one manner with the world. The problem is that certain paradoxes arise out of the language, for example the so-called 'liar paradox' described by Tarski (Chalmers 1990, p.151).

There is also the problem of the lack of convergence of theories in the history of physics. The wave-particle duality might be one such example of lack of convergence. A second problem is that there are occasions when a number of alternative theories will explain a set of facts with seeming adequacy. For example, the alternatives within the electromagnetic theory allow for fields occupying space in contrast to localised charges acting at a distance, although both alternatives are empirically adequate.

Another problem for scientific realism is the difficulty with the notion of causality. The standard view assumes the existence of the physical principle of causality (Riggs, 1992) such that "in principle all events in the natural world have a cause" (p. 143). However, the principle of physical causality breaks down in quantum mechanics theory because not all physical events need to be caused. This was demonstrated in the Einstein-Podolsky-Rosen thought experiment for action at a distance.

A further problem is the introduction of the laws of chance into physics as a fundamental and irreducible factor (Hesse, 1980). It is not only the apparent indeterminism of causality in quantum theory that introduces chance, but chance has always been a pervasive ingredient even in classical theory. To overcome the problem of chance, a number of explanations have been offered. The 'hidden-variable' postulate of Bohm is one response. However, according to O'Hear (1990) this and similar accounts are generally not favoured by physicists.

A further problem for the standard view of science is seen by Hesse (1988) to be the relevance of objectivist science to the problem of preserving human values and meaningful life interpretations for human beings. Hesse (1988) cites Husserl in stating that:

> As knowledge became progressively reduced to positivistic facts, 'objective' nature became split from the human psyche, and scientifically objectivised nature became 'true nature' and lost its concern with the meaningful basis of human life. (p. 183)

Husserl is not a relativist in the van Fraassen sense, according to Hesse (1988), because Husserl expresses admiration for the eminence of theoretical and technical success of the scientific process in its mathematical regularities and predicability. However, "what Husserl does not accept is that this objectivised (and as far as it goes objective) nature is all that there is in true Nature" (Hesse, 1988, p. 186). This point of view is similar to that of the populist scientist David Suzuki and others (Suzuki & Knudtson, 1990) who advocate a code of ethics being proper to the discipline of science in the pursuit of, say, bio-engineering.

Scientific literacy within the discourse of science requires the ability to modify the views of scientific realism in response to problems such as those identified by the science philosophers above. Some of these processes of modification are briefly discussed in the following examples.

Examples of Modified Views of Scientific Realism

The above discussion of the inadequacies of the standard view for scientific realism leads to an examination of five examples of how views of scientific realism can be modified.

A multiple theories view. One such modifying view is that of Duhem (McMullin, 1990). Duhem attempted to find a middle way between the two positions regarded as extreme:

> Duhem notes the fertility and unifying power of the abstract laws of physics and urges that these cannot possibly be an accident; they are best explained by supposing these laws to reflect realities whose essence cannot be grasped by the methods of science. (p. 427)

The middle-ground position of Duhem is supported by Hacking (1988) who states that a "description of mature and successor [sic] normal science strongly resembles Duhem's anti-realism about theories" (p. 513). Hacking attributes to Duhem the conception that nature is too complex to admit of a single unified description and the best that can be achieved is a complementarity of mature theories that need not be commensurable with each other.

Transcendental realism. A second modifying view of scientific realism is that of Bhaskar (1975), who synthesises three positions in modern philosophy of science. They are 'empirical realism' on one hand, 'transcendental idealism' on the other hand, and 'transcendental realism' in the middle. Empirical realism is concerned only with objects of perception. Transcendental idealism sees scientific knowledge as models or ideals of the natural order. Bhaskar (1975) states that under idealism "the natural worlds become the construction of the human mind" (p. 25). However, the position adopted by Bhaskar (1975) is that of transcendental realism:

> That the world is structured and differentiated can be established by philosophical argument, though the particular structures it contains and the ways in which it is differentiated are matters for substantive scientific investigation. (p. 29)

Transcendental realism according to Bhaskar is the answer to three related mistakes of the empiricist according to Bhaskar (1975):

> The first consists in the use of the category of experience to define the world. This involves giving what is in effect a particular epistemological concept a general ontological function. The second consists in the view that its being experienced or experienciable is an essential property of the world; whereas it is more correctly conceived as an accidental property of some things, albeit one which can, in special circumstances be of great significance for science. The third

thus consists in the neglect of the (socially produced) circumstances under which experience is in fact epistemologically significant in science. (p. 28)

Bhaskar's (1975) transcendental realism includes an independent existence both of the world and of our knowledge of it, understanding however, that knowledge based only on empiricism is not always reliable.

Unrepesentative realist view. A third modifying view of scientific realism is given by Almeder (1989). The view that beliefs are correct descriptions of the external world is problematic according to Almeder (1989), following in the tradition of 'the structure of scientific revolutions' of Kuhn (1962), who claimed that science was not something objective but merely the consensus of the relevant scientific community. Almeder (1989) proposed a number of limitations about scientific realism. Such limitations are: there cannot be a claim that there is a best possible empirical solution or that there is only one possible solution; there cannot be a claim to explain the general success of science or that success comes from the theories adopted; there cannot be a claim that any one propositional statement succeeds in describing the real world.

Almeder (1989) then discusses the totally anti-realist position of various forms of relativism. Eight anti-realist responses are discussed to see if an anti-realist position is better than the proposed modifying realist position. The conclusion is that the anti-realist arguments still do not answer the question about the predictive success of science. A modified realist view is adopted by Almeder because it allows belief in an external world but not necessarily belief in accordance with the correspondence theory. This position is similar to that of Chalmers (1990), who uses the term 'unrepresented realism' to include two aspects of realism but discards a third as follows:

> Firstly, it [unrepresented realism] involves the assumption that the physical world is the way it is independently of our knowledge of it... Secondly, it is realist because it involves the assumption that, to the extent that theories are applicable to the world, they are also applicable, inside and outside of experimental situations...
> [Thirdly] the unrepresentative realist does not assume that our theories describe entities in the world, such as wave functions or fields, in the

way that our common sense ideas understand our language to describe [objects such as] cats and tables. (p. 163)

Constructive empiricism. The position of Chalmers and Almeder is different from that of Van Fraassen (1980), who argues for a prerequisite empirical proof for theoretical positions and calls this position 'constructive empiricism' (p. 11). Van Fraassen explains: that scientific theories and laws are not required to be truth-corresponding but only empirically adequate; that scientific theories are not to be asserted as true, but simply displayed as possible truth; that scientific theories neither affirm or deny hidden structures or variables. Cartwright (1983) calls this 'sophisticated instrumentalism' which does not engage the real world. However, recognition of the role of language in modifying scientific realism by van Fraassen is an important contribution.

Van Fraassen (1980) recognises the role of language in the scientific realism debate and raises the question about the literal or interpretive construction of language depending on the empiricist or the realist stance taken. Van Fraassen (1980) believes in the interpretive use of language such that not only is there a theory-ladenness about observations but also a theory-ladenness about the language of science: "The way we talk and scientists talk is guided by the pictures provided by previously accepted theories" (Van Fraassen 1980, p. 14).

However, while recognising this aspect of language, Van Fraassen accepts the modified realist view that language is here to stay:

> All our language is thoroughly theory-infected. If we could cleanse our language of theory laden terms, beginning with the recently introduced ones like 'VHR receiver', continuing through 'mass' and 'impulse' to 'element' and so on into the prehistory of language formation, we would end up with nothing useful. (p. 14)

There is a role in scientific literacy in the discourse of science not only for deconstruction of text but also in deconstruction of theory. For example, it is possible to consider two theories of what the world is like and construct an empiricism to support either, from Rutherford's atomic theory, or from Vaihinger's hypothesis that without the concepts of electrons and other atomic particles, the world would not be different. Another example is to construct the empirical view that Thomson's invention of the electron came from a view of electricity being a fluid or bodies flowing in an electrically charged fluid, rather than from the more accepted field theory of Faraday.

The fallible science view. A fifth example of a modified view is Brown's (1979) new epistemology for philosophical research. Brown (1979) discusses the problem of infallibility and says that, "we must (either) deny that there is such a thing as scientific knowledge or free that concept from the concept of infallibility" (p. 151). Brown says there are three ways to meet this problem: scrap the concept of scientific knowledge altogether, continue to do philosophy of science in terms of logical empiricist research even while searching for a new epistemology, or thirdly to accept fallibility. It is this third way that Brown (1979) chooses:

> The third possibility adopted here, is to swallow the charges of relativism and historicism if need be, and make them the basis for a new philosophical research project to be built on the failures of logical empiricism, a project which begins by accepting the analysis of scientific knowledge as the fallible body of accepted science (p. 152).

Brown (1979) concludes that there is need for constant transaction between theory and observation, where theory determines what observations are worth making and how they are to be understood, and observation provides challenges to accepted theoretical structures. Brown (1979) recognises that the resolution of conflict between theory and observation or between theories is not made by the application of mathematical rules but by reasoned judgement on the part of scientists and "this admittedly fallible process is offered as a paradigm of a rational procedure" (Brown, 1979, p. 166).

The recognition of such fallibility is middle ground between naive scientific realism and the extreme relativist position of sociological construction of knowledge adopted by Bloor (1976), Barnes (1972) and others. A modified view of scientific realism rejects the "anarchist" view of Feyerabend (1975).

Modifying Scientific Realism for Scientific Literacy

These five examples of modified versions of scientific realism are supported in the literature and can be adapted to the social realities in which they apply without espousing the radical constructivism of Latour (1987), for whom scientific facts are socially constructed through complex social processes. The concluding argument here is that any of the modifying versions of scientific realism such as described in the above five examples, are consistent with the definition of scientific literacy as activating cognitive processes in the discourse of science. This position is summarised as follows.

Scientific literacy is directed towards modifying the views of scientific realism through the discourses of science. It may be that an external world exists and that some of these beliefs, including the potential of our theoretical ones, are correct descriptions but that the correct match between science and the real world is unknown.

This view of modified scientific realism fits into a social construction of education that science is not the only way of knowing but one that it is an essential part of knowing. The place of science in education is described as a necessary element in cultural and scientific literacy by Hazen and Trefil (1992) as follows:

> Science is not the only way, nor always the best way to gain an understanding of the world in which we find ourselves. Religion and philosophy help us to come to grips with the meaning of life without the need for experimentation and mathematics, while art, music and literature provide us with a kind of aesthetic non-quantitative knowledge. You don't need calculus to tell you whether a symphony or a poem has meaning for you. Science complements these other ways of knowing, providing us with insights about a different aspect of the universe. (p. 2)

The advantages of using modifying approaches to scientific realism are supported by Lemke (1990):

> Our best protection against authoritarian use of the notion of 'facts' is a critical view of how (and why and by whom) such statements are made. The belief that there are absolute facts creates the power for someone to say what the facts are. It is always someone, or some group, that in practise does say what the facts are (and what the correct rules of proof are, what legitimately counts as evidence and good argument and what does not). This power is inevitably abused. Its foundation is a belief in absolute facts that we can do very well without. (p. 142)

Upon entering the discourse of science, the proposed definition of scientific literacy requires communication of this discourse in the language register of science. The level of discourse about competing theories of reality may be beyond the scope of secondary school students, however, they can be awakened to such discourse through the activities of scientific literacy. This project provided contextual readings for examination be students who can physically abstract relevant concepts from the readings and integrate them into prior knowledge schemes. Thus, scientific literacy is more than the knowledge and understanding of science outlined in the first referent area of the literature review. It includes activating cognitive processes to modify our views of reality.

Defining the Language Register of Science

A Sociolinguistic Language

One view of the language of science is that it is not so much a sociolinguistic language as a cross-cultural language register with its own special vocabulary, symbol system and genres. In this view the language of science is regarded as a linguistic system independent of the primary culture. Widdowson (1979) assumes that there is a common scientific culture, or common enough for communication, that makes the scientific discourse independent of the primary cultural systems associated with different societies. The scientific discourse is therefore a secondary system to which people have access even though they belong to different primary cultures. Widdowson (1979) states:

> Scientific discourse is a universal mode of communicating, of universal rhetoric, which is realised by scientific text in different languages by the process of textualisation. (p. 52)

It is claimed that the variety of modes of communication such as formulas, equations, graphs, symbols, support the contention of this secondary universal system. Widdowson (1979) joins this to the notion of 'deep structure' used by Chomsky, as follows:

> One might indeed argue that non-verbal modes of communication (formulae, diagrams, charts, and so on) to some degree, at least, represent the basic elements or the 'deep structure' of the scientific

discourse of which the linguistic textualisations are the surface variants. (p. 54)

The deep structure is used as an example of the 'universal language' of Chomsky (1968). This view of the language register of science may be called an independent linguistic system.

In contrast, other writers such as Lemke (1990), Martin (1985) and Halliday (1978) would contend that the socialisation aspects of the dominant culture have created the conventions of the discourse, and cultural differences have been set aside. There is evidence for this in the forms of culturally determined, Western scientific language. The requirement for passive verbs, formal style, structured format and a methodical generation of vocabulary is evident in written scientific texts. This is a dependent linguistic system.

Whatever the outcome of the debate between independent and dependent linguistic systems, scientific literacy has been an activity in all cultures. The communication of cognitive activity in science is clearly sociolinguistic. The cultural conventions of communication have always been determined by dominant figures in various cultures such as a 'medicine man' in one culture, a 'philosopher' in another, and a 'scientist' in other cultures.

Whether the language register of science is independent or dependent is a dilemma for science teachers because its formal use, in the dependent sense, is reinforced by the demands of syllabus and curriculum guidelines. For example, the Physics Stage 1 Extended Subject Framework (SSABSA, 1991) specifies scientific literacy as an objective defined in terms of a language register of the Western culture. Also, written prose in science is required to meet fluency and coherence criteria in the context of formal English usage in the Writing Based Literacy Assessment (SSABSA, 1992).

Compounding the dilemma is the situation that exists in most science classrooms, that there is likely to be a significant proportion of students with non-English speaking backgrounds, for whom the formal English language register of science may be inhibitory.

One solution is to adopt an integrated English-Science course in which the use of scientific language is the main aim. Examples of this approach are the Nucleus course (Bates & Dudley-Evans, 1981) and Intermediate

Scientific English (Chaplen, 1985). The principal aim of such a course is stated as follows:

> The principal aim of general science (Nucleus) is to develop an understanding of the language essential to scientific and technological communication and a confidence in using it. (Bates & Dudley-Evans, 1981, p. 5)

The course uses scientific reading texts to teach the processes of science. The Chaplen (1985) text teaches sentence structure, verb tenses, (particularly passive voice for science), scientific vocabulary and definitions, within various science topics. The English-Science courses advocate explicitly teaching science stylistic norms.

An alternative method is to adopt the proposal of Lemke (1990) that stylistic norms are broken down, 'violated', during the learning of thematic content. Norm-violation proceeds through individual and class dialogue. Colloquial language is encouraged, personification of processes is used, and human experience is used as much as possible. The norm-violation method is used during the learning of thematic content, and then only after mastery of thematic content are the strict genres of science taught. The experimental results of Lemke (1990) suggest that dialogue in the normal stylistic mode achieves a 20-25% class engagement while the norm-violation mode achieves a 90% engagement.

Accepting the fact that the genres of science are sociolinguistically determined, it is possible with the techniques of Lemke (1990) to recognise the development of the language register of science during dialogue, and to formalise this in the written genres. This development occurs through the sociolinguistic contexts of 'field', 'tenor' and 'mode', postulated by Halliday (1978) and briefly summarised here.

The Context of the Language Register of Science

The term 'register' is used by Halliday (1978) to describe the situation or context in which language is used. The contextual factors are the 'field', 'tenor' and 'mode', which refer to the type of social setting, the role of relationship, and the textual organisation. The structure in which these contextual factors find coherence is called the generic structure or 'genre' by Halliday (1978), and the use of genre as a device for coherence within the language register is described later.

The field. The term 'field' includes not only the subject matter as thematic content but also "the relevant actions and events within which the language is functioning" (Halliday, 1978, p. 32). The field of social action is different in the laboratory, the classroom and the computer room. This research is focussing on the activities of Year 11 physics students in the computer room.

The stylistic norms, according to Lemke (1990), in a conventional language register of science, are made formal by the avoidance of personalities, including historical figures and events, avoidance of fiction, avoidance of narrative and dramatic accounts. The stylistic norms can be supplemented by related aspects of field such as computer simulations, drama and role playing, creative writing such as science fiction. It is in this field of interaction at the computer work stations that constructive dialogue can take place between the teacher and student and is an integral part of implementing the plan for scientific literacy in this project.

The Tenor. The term 'tenor' refers to the role structure and "the selection of interpersonal options" (Halliday 1978, p. 144). The tenor is the role relationship between students and teacher or between student and student that is created at computer work stations in the computer room. In this research the roles assumed by the students are 'talker' and 'writer' and the roles assumed by the teacher are 'talker' and 'helper'.

The interactions between students and teacher that occur at the computer work stations assist in breaking down the stylistic norms in order to achieve meaningful learning before the writing phase is commenced. It is called here constructive dialogue and later in the report, duologue for the student initiated one-to-one interaction. The rapport established during the dialogue phase may enhance the teacher's role of 'helper' during the writing phase.

The mode. The term 'mode' refers to the symbols organisation of text, and "is the selection of options in the textual systems" (Halliday 1978, p. 144). In the case of a laboratory exercise, the mode of the language register is partly oral and partly written. In this research project, the mode is a combination of constructive dialogue, computer manipulations, written composition and word processing.

The conventional stylistic norms of mode, according to Lemke (1990), are avoidance of colloquial forms of language, the use of third person pronouns, and the use of technical terms including specialised words and symbols. The activities of the scientific literacy development plan (Figure 1.1) are designed to increase vocabulary through concept mapping, inferential reading, constructive dialogue, and display of writing models with various stylistic forms.

In summary, field tenor and mode are the sociolinguistic contexts of the language register of science and in Halliday's terms are used in classrooms during the oral, written and non verbal interactions. The constructive dialogue can be called the "talk curriculum" (Booth & Thornley-Hall, 1991)" or "talking science" (Lemke, 1990). The register not only provides the vehicle for communicating the discourse of science but also serves to activate the cognitive processes in the discourse of science, thus serving the definition being developed here.

The third referent area of the literature review, the language skills, is incorporated into this definition as the mode of the language register of science. However, the language skills are not the primary focus in this definition, but were seen as an essential component in language acquisition as illustrated in Figure 1.1.

The Genres of Science

The genre is the structure that provides coherence for the register. It is "the semantic patterning that is characteristically associated with the 'context of situation' of a text" (Halliday, 1978, p. 134). In the case of the relevance of teaching genre for scientific literacy, Martin (1990) says:

> The major scientific genres (report, explanation, experiment) have evolved to structure texts which document a scientist's world view. The functionality of these genres and the technicality they contain cannot be avoided; they have to be dealt with. To deal with them teachers have to understand the structure of genres and the grammar of technicality. (p. 115)

The range of genres that form part of the language register of science are the recount, report, procedure, explanation, exposition, and discursive argument, as described by Callaghan (1989). Classroom activities that foster familiarity with and competence in all these genres are recommended by syllabus and curriculum developers. Lemke (1990) supports genre instruction as the second stage of using the language register of science, after the free flow of norm-violating dialogue described earlier.

The application of scientific literacy in specific genre teaching is regarded as crucial by Martin (1985) for redressing the elitism of power-language ratio.

> If children received explicit instruction in writing, for example, including models and direct teaching making use of knowledge about language, many more children would learn to write effectively than at present. And success in education depends on writing. But at present writing is not taught [sic]. Bright middle-class children learn by osmosis what is to be learned. Working-class, migrant, or Aboriginal children, whose homes do not provide them with models of writing, and who don't have the coding orientation (in Bernstein's sense) to read between the lines and see what is implicitly demanded, do not learn to write effectively. (Martin, 1985, p. 61)

Scientific writing in the discursive argument genre is typically found at the tertiary level, although some secondary students would be capable of mastering this genre. Typical essays for tertiary students take the form of the following examples (Hefter & Jennings, 1991):

Example 1:

How can we predict the behaviour of nature when our measurements are inherently limited by the Uncertainty Principle. (p. 156)

Example 2:

Is it appropriate to say that Lamarckian genetics is 'wrong' and Mendelian genetics is 'correct'? (p. 107)

Example 3:

Summarise the arguments put by proponents and opponents of nuclear power. Which of these are scientific arguments and which are not? (p. 87)

Questions such as these allow for the development of the scientific discourse comparing rational and relativist approaches to the conduct of science. However, the emphasis on the explanation genre in the physics public examinations, limits the pursuit of the discursive argument genre by secondary physics students. Nevertheless, a range of genres in scientific writing is used by senior secondary students and is reported in Chapter 6.

The Explanation Genre

The features of the explanation genre are relevant to the definition as are the features of the discursive argument genre. In order to make the definition of scientific literacy applicable, writing in the genre of scientific explanation was chosen for the proposed cognitive writing model. These features are described by Callaghan (1989) as follows:

> * Social Function: Factual text used to explain the process involved in the evolution of natural and social phenomena or how something works. Explanations are used to account for why things are as they are. Explanations are more about process than things. In the school curriculum, explanations are often found in Science and Social Studies.
> * Generic (Schematic) Structure: A general statement to position the reader; then sequenced explanation why/how something occurs (usually a series of logical steps in the process).
> * Language features: Focus on generic, non-human participants; use of simple present tense; use of temporal and causal conjunctive relations; use of mainly material (action) processes, some passives used to get Theme right. The Theme is what comes first in the clause and is what the clause (or message) is about. (p. 16)

Within the language register of science there are the specialised elements that are eminently suitable for the explanation genre. These elements consist of specialised vocabulary for definitions, the use of compound nouns and technical terms, and relational statements expressed in words, symbols and equations. Scientific text allows the formation of abstract nouns from concrete nouns. Noun phrases and verb phrases are used to make new definitions. Halliday (1990) found seven major difficulties encountered by readers of science texts. They were lexical density, technical taxonomies, interlocking definitions, spatial expressions, syntactic ambiguity, semantic discontinuity, grammatical metaphors. It is the task of the teacher not just to unravel the language of the above specialised difficulties, but to show the students how to unravel them.

New technological concepts, space technology and computer science are creating new forms of specialised vocabulary and new forms of expression. These expressions are becoming part of the science register of language. The proposed strategy to assist in the incorporation of these new forms of expression into the students' cognitive structure is by a computer-assisted method of transferring them from contextual readings to an essay concept map in the form of concepts and propositional statements.

It is by using the genres of science that students can express concerns about the impact of science on society which was the focus of the second referent area for scientific literacy in the literature review. Knowledge and skill in the discursive argument genre will enable students through scientific literacy to develop alternative reasons and explanations for things as well as advantages and disadvantages of proposed solutions to problems. Other genres not normally included in the technical range of genres for science, such as science fiction, poetry and drama, give expression to the affective domain. This domain is part of the human function for an activating scientific literacy. Concerns about the social impact of science are often first generated in the affective domain then refined and strengthened by cognitive processes.

Interim Summary: The Definition of Scientific Literacy

The proposed definition of scientific literacy has been expressed as a human activity within a theoretical framework using theories about cognitive processes, the discourse of science, and the language register of science. The definition is expressed in verb phrases, and hence being a human activity, it can be engaged in by all. This definition for scientific literacy is repeated here as a conclusion to the foregoing discussion:

> Scientific literacy is the human function of activating the cognitive processes in the discourse of science and communicating this discourse in a form of language register of science.

The definition implies that scientific literacy occurs in phases of developing the mental representations, the language of thought, the meaning of reality, and communication in a variety of ways including the explicit genres of science. The definition supports the socio-semiotic purpose that scientific literacy is a human activity and is accessible to all.

This definition is comprehensive and is congruent with much of the referent areas in the literature review of Chapter 2. It is different in that it expresses the notion of scientific literacy in verb phrases and uses cognitive theories as bases so as to provide a framework for the various aspects of scientific literacy. An application of the definition is made now to the design of empirical research into scientific writing.

Applying the Definition to Scientific Writing

In order to test the proposed definition in the practical situation of classroom teaching, the application of the definition to writing in explanation genre was chosen to be a focus in this study. The definition is more applicable to cognitive styles of writing as distinct from affective styles of writing, or what Lemke (1990) calls literary styles of writing. Affective processes are described in the Bloom and Krathwohl taxonomy of educational objectives (Isaac & Michael, 1985). The affective processes such as receiving, responding, valuing, and characterising episodic and experiential memories are used in imaginative, expressive and emotive writing, for example in drama, poetry and fiction. All writing is a mix of both affective and cognitive processes because of the very nature of being a human activity. However, "probably the most important and neglected kinds of genres are the non-literary written genres" (Lemke, 1990, p. 200) for the reason that "very few of us will write novels, plays, or short stories, but most careers and lives make use of the skills of writing non-literary genres" (p. 200). To apply the definition of scientific literacy to the explanation genre of writing, the cognitive processes of writing require some discussion.

As an advance organiser for the discussion about the application of the theoretical definition to a cognitive writing model, Table 3.1 is presented here as a summary of the connectivity between elements of the definition, the cognitive processing units discussed above, and the application of these in a HyperCard Pathways writing model (HCP) of writing using hypertext features.

Table 3.1

Summary of the Definition and Model for Implementation

Definition of scientific literacy		Cognitive writing models	
Elements of the definition	Cognitive processing units	Features of hypertext	HyperCard (HCP) Pathways model
* activating cognitive processes	* central executive processing * memory processing	* representational schema with links and nodes	* concept mapping with propositional links
* in the discourse of science	* genre scheme processing	* pathways of individual choice	* reading texts * scientific genres
* communicating in the field, tenor and mode of...	* central executive processing	* editing facilities	* spelling checker * grammar checker * counting checker
* the language register of science	* language processing * dialogue	* models * contextual readings	* dialogue * definitions * paragraph structure

Cognitive Writing Processes

Cognitive theories of writing are proposed by Collins and Gentner (1980), Bereiter and Scardamalia (1987), Flower and Hayes (1980) and others. The general aspects that distinguish the cognitive modes of writing from the affective modes are the processes of idea production, the structure of the content, and the stylistic devices or genres used for specific purposes.

The cognitive processes are to do with comprehending, translating, interpreting, extrapolating, analysing, synthesising and evaluating knowledge. The forms of writing using cognitive processes are creative, expository, and explanation writing. They involve the conscious activities of structuring concepts, using propositional statements to link concepts, and textualisation processes.

The main cognitive theories discussed earlier, Classicist and Connectionist theories, propose certain mechanisms by which the cognitive processes bring about conscious activities such as writing.

Classicist Processes

The Johnson-Laird model of consciousness in Classicist theory (Johnson-Laird, 1988) would identify consciousness with a 'Superordinate Operating System' that monitors and partly controls a number of subordinate symbol processing units in parallel that are hierarchically organised. This model has deficiencies in the explanation of consciousness such as the self-reflectivity problem that seems to propose a model of itself in itself. Nevertheless, the model is useful in recognising the higher level faculty of organising and predisposing outcomes from lower level processes such as short and long term memory retrieval.

An illustration of the use of the higher order faculty is revealed in the 'thinking-aloud' protocols used by Hayes and Flower (1980). These are seemingly mental acts of short duration between verbalised acts in the protocols which are interior to the thinker (Bereiter & Scardamalia, 1987). These mental acts of short duration are postulated to be memory searches, comparisons and inferences, and they rise to the conscious level only after subordinate processing. The importance of these mental acts of short duration for writing is described by Bereiter and Scardamalia (1987) as follows:

Clearly much of the interesting work of composition goes on in between the points that are mentioned in thinking-aloud protocols. It consists of mental acts of short duration (comparisons, memory searches, inferences, etc.) of which only the major outcomes rise to consciousness. Yet it would seem that much of the success or failure of writing must depend on these processes. At the conscious level success might depend on thinking of the right idea. But whether or not one thinks of the right idea and thinks of it at the right time might depend on a variety of undetected production factors: on the speed at which the memory is searched, on the length of time information is held in short term memory and the speed with which it placed in more permanent storage, on the number and nature of competing demands for attention, and on the efficiency with which one can program the switching of attention among competing demands, and a host of other competing factors of this sort. (p. 849)

The 'Superordinate Operating System' of the Johnson-Laird model is one explanation for these cognitive writing processes.

Connectionist Processes

The Connectionist theories propose neural processing systems such as the Parallel Distributed Processing units postulated by Rumelhart and McClelland (1986). In this model of neural networks, activation patterns are established through feed-forward and bi-directional networks of neurones and their components. It is proposed in this theory that activation values at the synapses are successively adjusted by means of connection weights, until a stable pattern, namely a conscious activity pattern, emerges. Although aspects of this model are unsatisfactory, such as the failure to explain the causal function of phenomenal experience, some empirical data support the model. Speech loss, memory loss, and motor control have been associated with various types of lesions in specific parts of the brain. Memory loss is associated with bilateral damage to the hippocampus. The model proposes that inhibitory inputs to the self-adjusting connection weights may account for the difficulties that writers have with certain cognitive processes. Bereiter and Scardamalia (1987) explain:

The analysis has suggested three production difficulties...(a) short term memory loss, to which the slow rate of production could be a contributing cause; (b) interference from mechanical demands of the written medium that compete for mental resources with the higher level demands of content planning and the like; and (c) general discoordination of language production resulting from the lack of external signals. (p. 101)

Aspects of both Classicism and Connectionism are useful for postulating the processing units to explain cognitive writing. These informational processing units are reported by Bereiter (1980) and are described next.

The Cognitive Writing Processing Units

Bereiter (1980) proposed that computational information processing gives rise to cognitive writing through either processors (for the Connectionists) or thought processing units (for the Classicists). The scheme for describing these units is as follows:

Central processor/processing unit. This is a high level executive scheme directing the whole writing operation towards its purpose. It operates with the short-term memory. It is subject to overload such that the principal limitation on the complexity of cognitive performance is the number of mental schemes that a person can keep simultaneously active.

Genre scheme processor/processing unit. This is a lower level processing of knowledge according to the genre scheme for certain kinds of writing. It can be 'wired' by observation, instruction and scaffolding which contain intentions, game plans, categories of content, search procedures and tuning mechanisms.

Memory content processor/processing unit. Below the genre unit there is a content processor for extracting semantic material from memory in verbal and non-verbal propositions. It operates from the long-term memory.

Language processor/processing unit. There is a language processor that invokes explicit language directed towards the purpose of the writing and in keeping with the genre scheme required. It is 'wired' according to cultural experience such class, codes and control mechanisms (Bernstein, 1971), and is presented in either writing or speaking mode by the central processing unit.

These four thought processing units (for the Classicists) or processors (for the Connectionists) are used in the production of cognitive writing and can be observed in the models of writing produced. The task here is to relate the processing scheme with the observed models of cognitive writing and hence devise a model of activating the cognitive processes in scientific writing. The cognitive processes of writing can then be used in the discourse of science according to specific genres. The discursive argument genre of writing can be used, for example, in the rationalist versus the relativist debate. The explanation genre can be used in developing a different modification of scientific realism. The human thought processing units are activated and the discourse is expressed in cognitive writing and hence the whole process is an application of scientific literacy.

Models of Cognitive Writing

The models refer to the way writers compose texts based on experimental evidence gained from the 'thinking aloud' protocols of Flower and Hayes (1980). Subjects are asked to say aloud everything they think and everything that occurs to them while performing the task, no matter how trivial. Other techniques such as blind writing, forced divergences and task interruptions were used by Bereiter and Scardamalia (1987).

Writer-Based Process Models

Writer-based prose was the term given by Flower (1979) in which the characteristics were that writing was primarily executed from a coherence-to-the-writer perspective rather than coherence-to-the-reader perspective. According to Flower: "Writer-Based prose is a verbal expression written by a writer to himself or herself. It is the record of his own verbal thought" (1979, p. 19). Three models of writer-based prose are discussed here.

The 'think-it-say-it' model. The protocol analyses of Hayes and Flower (1980) clearly identified the 'think-it-say-it' model of writing where the focus was on the writer rather than the product. The analyses indicated a close relation between conversation and written text. It conforms to what Bereiter and Scardamalia (1987) call a 'knowledge telling' mode of writing. Knowledge telling is based on personal experience for ideas and relies on oral discourse for its structure. Ideas are generated by recounting experience. The model is described by Bereiter and Scardamalia (1987) as follows:

> The solution is natural because it makes use of readily available knowledge — thus it is favorable to report of personal experience — and it relies on already existing discourse, production skills in making use of external cues and cues generated from language production itself. It preserves the oral straight-ahead form of oral language production and requires no significantly greater amount of planning or goal-setting than does ordinary conversation. (p. 9)

The research of Flower and Hayes (1980) showed that the 'think-it-say-it' model was common for school age children to about Year 10. The process is further described by Bereiter and Scardamalia (1987) as follows:

> From that point on it appears that much of the cuing of memory comes from items already generated, with continuing input from the genre schema, leading to a rambling string of ideas which nevertheless culminates in an appropriately formed story that sticks to the assigned topic. (p. 21)

The 'think-it-say-it' model is not necessarily just an early developmental stage of writing, but it is usefully employed in what is called 'journal writing' in classrooms. There are two reasons why this form of writing is effective: first, there is no overload on the central processor unit, the short term memory; second, alternative perspectives do not have to be analysed. The typical start-up time for this form of writing was shown to be quite short.

This model of writing may be suitable for scientific writing in the form of recounts or experimental reports. The disadvantages for analytical scientific writing are that complex concepts are not developed because the content processor for extracting related semantic material is not accessed and hence conceptual re-structuring is not attempted.

The 'writing-for-discovery' model. The writing-for-discovery' model is proposed by Odell (1980) in which the very act of writing serves "as a means by which one discovers what one wishes to say" (p.143). It is the form of writing that a writer uses to discover what is called the 'centre of gravity' of the writer's own assertions. The 'centre of gravity' is some implicit assumption that has largely been unidentified in the writer's thoughts. Odell (1980) used techniques in which writers sought to identify this 'centre of gravity' through free writing forms. Writing for discovery may serve as first draft writing or it may stand alone as a piece of creative writing. An example of creating writing is Joseph Epstein's "Thinking" (Aaron, 1987). The discovery of a definition of thinking is made through writing for discovery:

> True thinking is an act of discovery made on a voyage that everyone must take on his own. Forgive me for saying so, but before I sat down to write this essay, I never thought of that. (Aaron, 1987, p. 372).

Sharples and Pemberton (1992) characterise this form of writing as 'Beethovian' in contrast to 'Mozartian'. Beethovians create text in order to find out what they think. As the text emerges it serves to direct the search of long term memory and to constrain the selection and organisation of ideas. The Mozartians produce detailed plans before text, and write according to product-based models described later. The discovery model may be useful for identifying implicit assumptions not previously made explicit, as noted by Odell (1980), for example in the framing of hypotheses for testing. The lower level content processor for related semantic material is being accessed.

The metaphoric model. The use of metaphors can also become a writer-based model when used as a strategy for inventing ideas rather than as a stylistic device. Jules Verne, the nineteenth-century science fiction writer, had visualised a cannon as a launching device for a trip to the moon, but a cannon expends all its force at once and at the start, when the atmosphere is thickest and offers the greatest resistance. The total acceleration is attained at the very start and would crush any human inside the vehicles. Nevertheless, the metaphoric story inspired further scientific and technological research until the task of a mission to the moon was achieved.

Similarly Asimov's "I Robot" (cited in Asimov, 1984) science fiction was a source of inspiration for further inventors. It was written in metaphoric style, as if it were true, and the robot obeyed the three laws of robotics which formalised its relationships with humans, a desired goal even today. Science fiction requires access to a content processor, but connectedness of concepts within the parameters of scientific realism is not a high priority.

Writer-based process models are more likely to be utilised in recount genre scientific writing, in which imaginative biographies can be created or science fiction personal accounts. The literary genres such as poems would also be applications of scientific literacy within a writer-based process model of cognitive writing. However, it is in the product-based stage models that scientific explanation genre is more likely to reside.

Product-Based Stage Models of Writing

In contrast to the writer-based process models of writing, these models refer to the cognitive processes involved in knowledge-transforming, (rather than knowledge-telling) processes, such as problem analysis and goal setting at the pre-writing stage. The distinctive processes are described by Bereiter and Scardamalia (1987) as:

> The distinctive capabilities of the transforming-model lie in formulating and solving problems and in doing so in ways that allow a two-way interaction between continuously developing knowledge and continuously developing text. (p. 12)

The observable difference between knowledge-telling and knowledge-transforming is in start-up time, planning notes, thinking-aloud protocols, and revisions. The protocol analyses suggests that among expert writers there was a great deal of mental activity not directly represented in the text. A number of product-based stage models are now discussed in preparation for proposing a new cognitive writing model for the application of scientific literacy.

The 'pre-write, write, re-write' stage model. The 'pre-write, write, re-write' model treats writing as a gradual process of development. In the extreme it holds that composition proceeds in relatively discrete stages. The pre-writing stage is for the generation of ideas which can range from library research, sensory experience, reflection in times outside of the task time. Writing a draft is then followed by review and re-writing. This model is commonly found in curriculum documents and teachers' assessment plans which require evidence of three stages of a submitted pieces of work.

Staging is one of the principal techniques advocated in English for Special Purposes (ESP) programs (Swales, 1984). The writing of English for Academic purposes (EAP) is product-oriented in the extreme. For example, the elements of each section of the writing a research thesis are stipulated in detail by Murison and Webb (1991). However, the research of Flower and Hayes (1987) showed that writers rarely follow a tidy sequencing of stages, and there is interaction between each stage. The metaphor of a 'cook' is used by Flower and Hayes (1987) to illustrate the staging model in contrast to the 'juggler' metaphor of the recursive process in the next model.

The recursive stage model. Flower and Hayes (1980) suggest there are three general operations in writing: planning, translating and reviewing. Planning has three types of sub-operations: generating, in which the writer retrieves information from the long term memory; organising, in which the most useful of the retrieved items are organised into a plan; and goal-setting, in which the task is addressed. Results from protocol analyses (Bereiter & Scardamalia, 1987) indicate that there is a recursive, back and forth, processing throughout the whole composition. At each stage of composing a proportion of time was spent returning to other stages, and hence illustrates the recursive nature of this model. For example, during the organising stage, it was found that 66.7% of the protocol time was spent on organising; 18.3% was spent going back to organising; 5% of time was spent going forward to translating and 10% going further forward to review and edit. This interaction within all stages progresses with changing proportions until the final editing is accomplished. This model is often referred to in the literature as the Flower and Hayes (1980) model. A similar model is described by Gould (1980) to include pause times, and the planning phase is reported to begin even before the generating phase and to continue with decreasing attention until the end of the task.

The recursive model of writing is clearly that of a metaphoric 'juggler', in which a number of the process are kept in the air by using all cognitive processors simultaneously (the central processor, the content processor, the language processor and the genre scheme processor), depending on the skill of the writer. This model is clearly suited to complex scientific writing.

The interruptive sub-process model. Bereiter and Scardamalia (1987) postulate that an interruption can occur at any stage in the composing process in the transition from knowledge-telling to knowledge-transforming. The model is thus a sequence of feedback loops which end at the point where the interruption was first made. The interruptive process has three sub-processes: compare, diagnose and operate (CDO). It is described by Bereiter and Scardamalia (1987) as follows:

> During the course of composition, two kinds of mental representations are built up and stored in long-term memory. These are a representation of text so far, and a representation of the text intended,

which includes the whole text, not just parts already written. The CDO process is initiated by a perceived mismatch between two representations. (p. 266)

In three studies on children's composing, Bereiter and Scardamalia (1987) demonstrated that children can signal CDO sub-processes without a loss in concentration. An interruption even at every sentence did not lead to a decline in performance. It was anticipated by the researchers that mature writers would do a good deal of CDO in their heads either as planning or revising. The researchers used procedural cuing, instructor modelling of thought, and direct strategy instruction for two types of writing, opinion essays (discursive argument or expository argument) and factual exposition (explanation) essays, to show that the CDO process can take place in both planning and revision stages. After extended instruction, two 50-minute lessons a week for 19 weeks, "all indications were that progress in the direction of a knowledge-transforming approach to writing" was taking place (p. 314).

In studies into the development of student progress into more sophisticated text processing strategies, Bereiter and Scardamalia (1987) found that topic-based strategies for knowledge-telling gave way to proposition-based strategies for knowledge-transforming in the writing of compositions. The mental representations of a fully comprehended text "consists of hierarchical arranged propositions (p.240). They are described by Bereiter and Scardamalia (1987) as:

At the top of the hierarchy are topics that indicate what the text is about. At the lower level are propositioOns that summarise major substantive points in the text. (p. 240)

The product based models described here employ cognitive processes during all stages of composing. The processes include language production, evaluation, tactical decisions, and executive control of the overall process. These cognitive processes match the processor/processing units schema of the Connectionist/Classicist theories described earlier and illustrated in Table 3.1. Given that these cognitive processes are mimicked by computer processes, it can be seen that computer-assisted writing models are worthy of discussion.

Computer-Assisted Writing Models

A number of different approaches have been taken in the development of computer programs to assist writing. They can be considered to be examples of making the definition of scientific literacy applicable to students.

Hartley (1990) describes three levels of computer-assisted writing: first level word processing for deletions, substitutions and rearrangements of text which lead to better drafting techniques; second level post-writing editing for spelling, grammar and writing style checks, which lead to better revising techniques; third level hypertext procedures for interactive routines that assist throughout the composing process such as planning, organising and linking, which lead to better knowledge-transforming techniques. Development of these third level programs is in its infancy according to Hartley (1993) but preliminary results of studies reported in Hartley (1993) indicate that significant change to cognitive writing strategies occurs only at this third level of computer assistance.

First level word processing. Simple word processing consists of facilities to cut, paste and re-arrange text. There are a number of commercial packages written for these purposes which can be used recursively as in the Flower and Hayes (1987) model. It is debatable whether word processing represents a different model of writing distinct from those already described.

On one hand, results (in Hartley, 1992) indicate there is increased revising and drafting but no significant improvement in the quality of writing after use of simple word processing. On the other hand, Silver and Repa (1993) using 'Word Perfect Junior' report an improved quality of writing using the 'CUNY writing skills assessment test evaluation scale' in their study. Robinson-Stavley and Cooper (1990) report inconclusive results at this first level of computer-assisted writing, when assessed separately from the second level.

One example of the value of first level word processing is the development and provision of the 'undo' facility. Yang (1992) reported the beneficial effects of not just a one-step-back 'undo' but a revision trace facility by which the history of revision was monitored and available for recall at any previous step-back. It can therefore clearly assist the central cognitive processor of the writer in making multiple revisions beyond the capacity of the human short term memory.

At the first level word processing, presentation can be improved through style devices such as 'bold', 'underline', 'italic' and use of a variety of fonts. These allow increased satisfaction with the product.

Second level post-writing editors. Post-writing tools are checkers of various forms for spelling, grammar, style and document statistics. They assist with measures such as sentence length, and the number of passive verbs. Software trials by Assink and Linden (1993) indicate that a five module computer program increased students' learning of spelling and grammar rules compared with control groups. This applied particularly to poor spellers.

Robinson-Stavley and Cooper (1990) report that studies using 'Writer's Workbench' designed to study writing style at the word and sentence level, indicated improvement in quality of writing. In contrast to other studies, they were able to show that longer essays, more complex sentences and fewer punctuation errors were produced. Positive attitudes towards computers and writing were engendered. Hartley (1993) cites studies that show no significant differences between scores of trial and control groups in the overall quality of post-test essays.

A specific purpose editor designed for teaching English as a second language was produced in the Eikeli project (Hovstad, 1989), in which extensive document statistics list the frequency of certain mistakes, and average word, sentence and paragraph lengths. It incorporated synonym finders and vocabulary prompts to assist the students. The project was regarded as successful and indicates the value and variety of post-writing editors.

The studies of Hoard, Wojcik and Holzhauser (1992) of an automated grammar and style checker for writers of simplified English found that this level of computer-assisted writing was effective. They produced a 350-rule English grammar and parser with special functions that checked violations of the Simplified English standard. It is being used for writing aircraft maintenance manuals at the Boeing Advanced Technology Centre. Similarly, a controlled English grammar based on a limited vocabulary range and controlled sentence structures was developed for engineers. This reduced the reading difficulty of technical documents and is being used at the Bell-Acatel training centre for engineers (Schreurs & Adriaens, 1992).

It seems that post-writing editors are generally helpful in the final stages of writing but they are generally divorced from organisation and evaluation of meaning according to Holt (1989) and further development working is necessary.

Third level hypertext procedures. The term 'hypertext' was coined by Nelson (1974) to describe the non-linear methods of accession of knowledge first proposed by Vannevar Bush in 1945. It is defined as a non-sequential knowledge based system that presents different options to readers for creating their own pathways through the units of information (Collier, 1989). The components of a hypertext application are the interlinked units of information and the optional pathways to make those links. The units of information are called 'nodes' and the interlinking systems are called 'links'. The links enable the reader to move directly to any node of choice. The move is made from the anchor node to the destination node. The facility to create individual pathways is called navigation. Another component is a backtrack facility which enables the readers to return instantly to the starting point. Many systems also offer a review graphic of the links created in a single navigational exercise, which is referred to as a pathways analysis in this project and is used in the analysis of the writing products.

Hypertext procedures have been applied to the cognitive theory of writing by a number of authors. Neuwirth, Kaufer, Chimera, and Gillespie (1987) developed a hypertext application called NOTES to investigate the effects of computers on the writing process. They found NOTES assisted writers in transforming the note form of their ideas, reactions, inferences, and summaries from note form into prose. Alternatively, note-form can be created out of prose and examined from different perspectives. The authors drew a number of conclusions about the use of these transformations for creative writing and for expository writing. First, they concluded there was a direct relationship between the examination of concepts from different perspectives and the creativity and quality of writing. Second, they claimed that assistance to writers in moving from relatively isolated and detached concepts to an integrated structure was valuable.

Another application of the hypertext method is the 'Writing Environment' (WE) by Smith, Weiss, and Ferguson (1989). It is a hypertext application to create both electronic and printed documents. It was found that successful expository writing indicated that the writer's knowledge base was highly organised including superordinate concepts, precise meanings, analogies to other concepts, and explicit links among concepts. Rada (1989) developed a HyperCard software TEXNET to assist the collaboration of multiple authors and the conversion of a non-linear 'hyperDocument' into a linear printed document. It was designed to foster collaborative writing by a team of researchers. In contrast, the requirement in this research project was a model of writing for individual writers. The development of WRITER'S ASSISTANT (Sharples, Goodlet & Pemberton, 1989), was designed to assist the writer throughout the writing process by combining the facilities of a text editor, an ideas generator and an outliner or structure generator. It is designed to work within the Flower and Hayes (1987) recursive stage model of cognitive writing and comes closest to the model proposed in this research project.

An analysis of hypertext design features for reading materials by Wright and Lickorish (1989) indicted that the essential features were linkage style (alternative routes, signals, labels, control), destination appearance (displays, multiple windows, duration), and navigation support (signposting, backtracking, reader-created links). These features not only provide for more interactive reading styles, but also blur the distinction between reading and writing, as users assume more control over their own text creation and manipulation. This rapid interchange between concept mapping, reading and writing activities is an application of hypertext facilities in a recursive stage model of writing which could be used in this project.

Other models. Other computer-assisted writing models include creative writing with interactive fiction. STORYSPACE (Bolter & Joyce, 1989) allows the reader/writer to create personal pathways between episodes. It frees both the author and reader/writer from restrictions imposed by the printed medium. Andersen and Holmquist (1992) developed a narrative computer system in which the script can lead to a number of outcomes depending on the actions of the reader. Little (1992) researched the effects of computer story-building on reading comprehension, vocabulary and attitude to writing. Results in general were very positive, indicating that computer-assisted hypertext procedures have indeed improved the models of cognitive writing first proposed by Flower and Hayes, Bereiter and Scardamalia and others. It is to this use of computer-assisted hypertext procedures of writing that this project applies the definition of scientific literacy.

The critics of computer-assisted models of writing would hold that cognitive accounts of writing have not revolutionised the art of writing. An analysis of seven different media for composition was done by Sharples and Pemberton (1992). The media were paper, word processor, file cards, sticky notelets, black/white board, back of hand, and a dictaphone. They were analysed for eight properties required for communication. File cards were seen as adaptable, portable, supportive of re-ordering, supportive of non-linear organisation, permanent, supportive of annotation, supportive of indexing. Word processors were seen as having two further facilities support for browsing of large documents, and a re-usable end product. Computers, according to Sharples and Pemberton (1992), do not provide a panacea for all writing problems but offer another way of approaching the task.

A problem that occurs through the use of computers is what is known as computer anxiety. Hayek and Stephens (1989) found that achievement in computer science courses was inversely related to computer anxiety. There is no reason to believe that this would be different in computer-assisted writing. The measuring scale used was CAIN (computer anxiety index) and included factors such as previous use, parental use, gender and others. Another scale used by a number of researchers is CAS (computer anxiety scale). It supports the finding that researchers need to be sensitive to the presence of computer anxiety and to implement strategies to lessen this as much as possible. A reasonable summary of the effect of computer-assisted writing is provided by Hartley (1993):

> We might suppose that the greater the level of support (particularly if it is well designed) the more likely that the writing with word-processors will change writing skills, particularly with extended practice. This may be more true of software which intervenes than of programs which await requests from writers, especially novice ones. (p. 28)

Interim Summary

The hypertext model of cognitive writing is seen as a useful development of the cognitive writing models and was chosen for this project. The processes of hypertext closely resemble the four cognitive processing units described earlier: central processing directing the whole operation of cognitive activity, the genre scheme processing for the framework of the discourse, the long term memory processing for the inclusion of information from prior knowledge; and the language processing unit. A combination of various features from the above hypertext models was selected and developed into a new hypertext model that allowed rapid transitions between all stages of the writing process and the inclusion of both new concepts and concepts from prior knowledge. The definition of activating cognitive processes in the discourse of science can thus be satisfied by using a hypertext model of writing. The new model for scientific writing being proposed, is one such application of the hypertext procedures.

Proposing a New Model for Scientific Writing

The HyperCard Pathways (HCP) Writing Model

The new model is an application of hypertext procedures described above for generating concepts and propositions, structuring mental representations, creating knowledge-transforming text, and text editing by using HyperCard software. The aim is to meet the requirements for writing in the scientific explanation genre for novice writers of this genre. The computer-assisted features include the development of computer-assisted concept mapping from scientific texts, genre selection for writing/typing from the concept map, specific spell checking of new specialised vocabulary, and grammar checking for specific problems relating to the use of English. To integrate these facilities as a method of writing, a navigation pathways technique was developed. The pathways allow transitions between concepts in a physics topic, relational statements, the choice of genre, and the choice of features of the language register at the planning stage. At the generating of ideas stage, there are pathways through word lists, definitions, and reading texts. At the organising stage there are pathways through the techniques of concept mapping. At the translating and revising stages there are pathways through writing models, assessment criteria and text editing. The pathways were developed within the HyperCard software package for *Macintosh* computers.

HyperCard

HyperCard is a product of *Apple™ Computer Inc.* for *Macintosh* machines. It has been used in many hypertext applications as described by McAleese and Green (1990) in an analysis of the state of the art of hypertext use. The advantages of using HyperCard are seen by Boyle and Snell (1990) to be "extensibility, essential for adding intelligent navigation; availability, essential for testing and development; user interface, essential for acceptability" (p. 33). The disadvantages were seen to be the lack of "a graphical browser, into-links, stretch-text and multiple card displays" (p. 33).

The HyperCard software package was chosen for this research project, the Scientific Literacy Development Plan, for the following reasons: first, the *Macintosh* environment is well known to be user-friendly; second, it is available to all users of *Macintosh* machines as it comes free with every machine purchased; third, the use of *Macintosh* machines is increasing in secondary schools. HyperCard allows considerable choice in the creation of non-linear ways of linking of information. The routes taken by the individual users are called the navigation pathways. For ease of navigation, new *menus* were created and existing ones such as *file* and edit were modified.

Besides the hypertext navigation facilities, HyperCard also includes text creation and graphics tools which are required for concept mapping. The integration of these facilities make HyperCard a useful hypertext application for the development of modules in physics for scientific writing.

Language Acquisition and Concept Development

It follows from the theoretical framework developed in the first section that the integration of language acquisition and concept development into cognitive structures is facilitated by the use of the Cornell type concept map, contextual readings for concept extension, genre selection, constructive dialogue, and text editing, which are each described in the following paragraphs.

Cornell type concept mapping. Ausubel (1963) proposed the term 'meaningful learning' for acquiring personal cognitive structures and advanced five strategies to acquire meaningful learning: the subsumation of concepts, use of advanced organisers, progressive differentiation of concepts, integrative reconciliation, and the use of superordinate concepts. The best known application of these meaningful learning strategies is concept mapping as developed in the 'Learning How to Learn Program" in the early 80s by Novak and Gowin, (1991) at Cornell University.

The essential features of the Cornell type of concept map are hierarchical levels of concepts showing a general to specific progression, links and cross links showing connections between concepts, branching of subordinate concepts, and propositional statements of the relationships between the concepts. The concept map has an advantage over semantic networks and other forms of cognitive structure representations because of the hierarchical structure which makes it a useful scaffolding device for writing in the scientific explanation genre.

The personal creation of concept maps for explanation genre essays is a technique for activating the cognitive processes, as explained by Novak and Gowin (1991):

> We use the term cognitive map to indicate a representation of what we believe to be the organisation of concepts and propositions in a given student's cognitive structure. Cognitive maps are idiosyncratic, whereas concept maps should represent an area of knowledge in a way that experts in that field agree is valid. Experts will disagree on details of a concept map for any given body of knowledge, partly because views of key concepts in any field change constantly with new research, but most will concede that a well devised concept map is a reasonable representation. (p. 139)

Reading for concept extension. Selected reading texts can be prepared by typing them into *cards fields* in the HyperCard application. They can be made topic specific and hence can be used to extend the vocabulary and concept range of students. Words (concept labels) can be selected from the reading texts under 'group selection' and automatically transferred to the concept map. The new concept labels can then be integrated into prior knowledge structures and eventually integrated into the writing product.

Access to definitions of specialist scientific terms is made possible for students from any section of the HyperCard application using a choice of pathways. It is proposed that this will also extend their vocabulary and assist to form links with prior knowledge. In this manner the discourse of science can be developed in pursuit of scientific literacy. Lemke (1990) stated that:

> A particular recognisable combination of thematics, genre, and stylistic choices of rhetorical strategies and word choices can be called a discourse formation. (p. 203)

Critical reading, according to Richards et al. (1985), "is reading in order to compare information in a passage with the reader's own knowledge and values" (p. 238). In this hypertext form of reading, the concepts can be selected, rearranged and genre changed in the creation of individual compositions. This would enhance scientific literacy.

Genre selection. The necessity for the genre approach to scientific writing is to enable students to access the discourse of science as discussed earlier. The choices that can be provided in the HCP model are: recount in a narrative or biographical form, with the concept map in the form of a time line; report, for example, a structured laboratory report with the concept map is in the form of a word processing outliner; procedure written as an investigation for a future testing with the concept map is in the form of a flow-chart; explanation as a formal piece of writing with the concept map produced in a hierarchical structure with conceptual relationships as outlined earlier; exposition and discursive argument which takes an argumentative approach from one side, or alternatively from each side, and reflects the opinion of the writer based on empirical evidence.

It is possible for a student to experiment with the same thematic content presented in different genres. Examples of this approach are presented in the writing models in the modules of HCP specific to each topic.

The discursive argument genre has high potential for the development of relativist positions in the discourse of science. The issues raised in the earlier discussion on the sociology of knowledge allow entry into rational/relativist debate. It allows for the expression of value beliefs and their coherence with empirical science. It is possible to develop an implementation plan for the discursive argument genre using a cognitive writing model proposed here. However, it is the explanation genre that is the main focus in the field research of this project.

Constructive dialogue. The use of constructive dialogue within the program for scientific literacy fulfils two purposes: first, the necessity for norm-violating dialogue, as described earlier; second, the efficacy of voice-feedback for the extension of vocabulary and concept formation. It is possible to develop a 'pronunciation' button for each word in the topic word lists so that students can hear the new word being pronounced to them. The efficacy of voice-feedback for young children is reported by Lehrer, Levin, De Hart and Comeaux (1987).

> Results suggested that voice-aided word processing acted as a scaffold for young children's composition by promoting the acquisition of several components of preschool literacy including symbol-sound and sound-symbol associations and metacognitive awareness of the purposes and processes of writing. (p. 335)

Text editing for first and second level computer-assisted writing. The principal limitation of the HyperCard software is that it offers only very limited text editing facilities. There are elementary word processing facilities but no syntactic or semantic guides, such as spell checkers, grammars checkers and document statistics. It is possible for students to transfer the text of their written composition to a *word* or *works* document for use of the comprehensive checkers and document statistics display. An alternative is to employ a specific computer application such as *Grammatik* that offers even more comprehensive checking. These alternatives to using HyperCard software are probably advisable in ESL classes where time and assistance is available for direct teaching of the English form of style, grammar and spelling.

The advantages of remaining with HyperCard software in the science classrooms are first, considerable time can be saved by not transferring into another application. Second, a checker within the word processing would also be quicker than the fully comprehensive checkers. Third, specific checking can be customised to cater for specific topics in the physics course. The text editing is by prompt only, so that students do not lose control over, or the responsibility for, their own text composition.

In this way the HyperCard application can cater for the three levels of computer-assisted writing after Hartley (1993): word processing, post-writing editing, and hypertext organising and planning.

Navigation Pathways for Third level Computer-Assisted Writing

The provision of navigation pathways makes the third level of computer-assisted writing possible. This is the use of hypertext strategies. The choice of pathways between various activities of the HCP is made possible by a combination of *pull-down menus, buttons* on the *screen*, and a contents schema that allow for different ways of making transitions towards the final writing product. Students are able to proceed through the HCP modules at their own pace and according to their own pathways.

It is the aim of this new applied hypertext model to have simple pathways that are specific to the requirements of the writer. In this way it is hoped to avoid the three problems that critics find with hypertext (Raskin, 1989):

> In short, hypertext only sounds like a good idea. It tends to evaporate when looked at closely. There are three basic human interface problems: (i) the linkages are often either cumbersome, wrong for your needs, or trivial; (ii) the problem of what aspect of a word, phrase or picture you intend has not been addressed; (iii) a uniform and excellent human interface specification is both necessary and absent. (p. 329)

The development of modules in the HyperCard application provides an adequate construction model for scientific explanation writing.

Chapter Summary

The definition of scientific literacy as a human function has been developed within a framework of theories concerning cognitive processes, the discourse of science and forms of the language register of science. A model of cognitive writing has been proposed to apply the definition in a classroom situation. The elements of the definition were derived from the theoretical framework and then application of these elements was made to a new model for scientific writing, namely a HyperCard Pathways model of writing. A plan to develop and implement the HCP writing model for scientific literacy in classrooms is described in the next chapter. The plan is called a Scientific Literacy Development Plan (SLDP). Its development, refinement and testing are described in Chapters 5, 6 and 7.

The questions posed as difficulties at the conclusion of Chapter 2 (p. 52) can now be answered:

* To the question concerning the integration of all aspects of scientific literacy: an attempt has been made to incorporate most aspects of the meaning of scientific literacy that have been found in the literature, and to provide a coherent definition of the term based on cognitive theories.

* To the question concerning more science knowledge or more contextualised knowledge: the definition provides for a more contextualised knowledge rather than discrete knowledge *per se*. That is, scientific literacy is about reading the signs around us and incorporating them into our own cognitive structures, and expressing concerns of societal impact in the recognised forms of the language register of science.

* To the question concerning the pursuit of objective methods or subjective interpretations: under this definition, scientific literacy is about subjecting both so-called objective methods and subjective interpretations to scrutiny through the use of explicit writing genres in science.

* To the question concerning the focus of language instruction: integration of activities through a computer-assisted package in hypertext was developed here. Although writer-based models of writing are useful, it is the product-based cognitive model for the explanation genre that is the subject of this research.

The research design for testing the effectiveness of the model is presented in the next chapter.

CHAPTER 4
THE RESEARCH DESIGN

Introduction

The research design refers to three activities. The first was the review of literature on the use and meaning of the term scientific literacy (Chapter 2), followed by an examination and synthesis of theory to establish a framework for a comprehensive definition (Chapter 3). This definition has now been established in answer to the first research question asking how scientific literacy was to be defined. The definition is:

> **Scientific literacy is the human function of activating the cognitive processes in the discourse of science and communicating this discourse in a form of language register of science.**

The second part of the design refers to the development of the SLDP, in answer to the second research question concerning its components. The development of these components, described in next chapter, were related to the activities of language acquisition, concept mapping, constructive dialogue and extended writing within the HyperCard Pathways (HCP) modules specific to topics in physics, first illustrated in Figure 1.1.

The third part of the design concerns the conduct of classroom trials in order to answer the third and fourth research questions concerning, respectively, the overall effectiveness of SLDP and concurrence of the findings with specific elements in the definition of scientific literacy. The second and third parts of the research design are discussed in this chapter as a prelude to more detailed descriptions of each of the classroom trials and refinements to SLDP in Chapters 5, 6 and 7.

This chapter discusses the method for initially developing the SLDP, then its trialling and refinement in three phases of classroom research. The combination of qualitative and quantitative methods of data collection and analysis are discussed in the context of triangulation of methods. The limitations and assumptions of the research design used in the development of SLDP, classroom trials, and analysis of data are then summarised.

To fulfil the definition and to meet some of the concerns of ILY, recommendations of WRAP, requirements of the new South Australian Certificate of Education, needs of examination candidates, and needs of NESB students, a number of activities were required for an effective SLDP:

* language acquisition;
* concept mapping;
* constructive dialogue;
* extended writing.

These were illustrated in Chapter 1, Figure 1.1. The next task was to construct an integrated learning package to accomplish these activities. To establish what the components of this learning package would be, a number of steps were taken. The first step was to seek advice from literacy education experts. The second step was to conduct an pre-SLDP investigation among the students for their perceptions about scientific literacy, and to make a survey of typical science reading materials. The third step was to seek assistance from a computer expert into the design of a computer-assisted package that would link and integrate the activities of SLDP.

Advice from Literacy Education Experts

The literacy education experts consulted were the project officers of WRAP, research officers at SSABSA and the first WBLA project officer (named in the Acknowledgments). As a result of these discussions, the components for language acquisition were agreed to be elementary sentence construction, paragraphs writing, using the language register of science, and, after further developments and refinements, extended writing in the explanation genre of science.

These components were arranged in a sequence of lessons supported by a lesson pack of overhead transparencies made specific for certain topics in physics. These lessons in language acquisition were refined and developed throughout the classroom trials as described in the following chapters and they were integrated into computer-assisted modules for a number of physics topics. Participating teachers were encouraged to engage in constructive dialogue with students during the computer work stations along the lines of Lemke's (1990) norm-violations, and the setting thematic patterns.

Pre-SLDP Investigation

First a questionnaire was designed (Appendix 5.1) using previously established literacy criteria (Education Department of South Australia, 1991) for surveying student opinions and perceptions about literacy and commitment to writing in science and reading science. Second, a range of typical scientific reading material was examined. The materials were surveyed for their readability and text style. The results are reported in Chapter 5. It was clear from these results that most scientific readings needed to be edited and simplified if they were to be used. Students were interested in scientific readings if they were contextualised, that is, related to some form of application or human experience.

These findings suggested that short contextual readings in each topic could be incorporated into SLDP to enable students to see physics concepts being applied in a range of writing styles and genres. This was possible using techniques in the HyperCard application. The method of integrating contextual readings and applied concepts within the HCP modules is explained in each of Chapters 5, 6 and 7, as refinements were made after each classroom trial.

Assistance from a Computer Programming Expert

The advice from the programming expert (named in the Acknowledgments) was to use the HyperCard application because of its suitability for concept mapping and its versatility for use as a hypertext medium. This meant that concept mapping could be done with a modified form of the normal HyperCard graphics tools. The advantages of using computer-assisted concept mapping compared with the conventional pencil and paper technique were its versatility for students to make numerous changes during the construction of a concept map, and the speed with which these changes could be made. Other features are discussed in the later chapters.

The use of HyperCard as a hypertext medium for writing in science was seen as its main advantage. Through scripting within HyperCard, individual pathways through the various components of language acquisition, contextual readings, and concept mapping could be made available to students. Because of this hypertext facility, the model of scientific writing proposed in Chapter 3 is called a HyperCard Pathways (HCP) to emphasis the novel approach to the writing process. Not only did the various components need integration but also the components needed to be made applicable to particular topics, in this case physics topics within the curriculum framework. This was done by scripting the HyperCard program into specific topic modules which were called the HCP modules. Expanding and refining SLDP within HCP modules required a considerable amount of scripting, and assistance was readily given by the expert referred to above. The classroom trials led to refinements and improvements, as described in the later chapters.

The SLDP evolved through three phases of trialling and refining into a program of 12 lessons and thus the second research question concerning the development of SLDP was satisfied.

Trialling the Scientific Literacy Development Plan

The trialling of SLDP was planned in three phases: a pilot study, a first extended study and a second extended study. The pilot study was designed with a small number of classes (four classes) to enable the researcher to have close contact with the trialling teachers and students for each lesson throughout the trial period (four weeks). The data from this trial were then assessed by the researcher with assistance from the trialling teachers and with the supervisors of this study. This enabled the components of SLDP to be established more clearly and recommendations to be made for an extended trial. The first extended study was then designed with a quasi-experimental method using experimental and control groups to answer the third research question which refers to the general effectiveness of SLDP. Later, a second extended study was similarly designed to redress the inadequacies of the first extended study and to provide data for analysis in relation to the fourth research question concerning the concurrence of the findings with elements of the definition of scientific literacy.

A combination of data collection methods was used in each of the trial phases and this is summarised in Table 4.1. The analysis of data is presented after the discussion of the design of each of the three phases of the classroom research.

Table 4.1
The Combination of Data Collection Methods

Qualitative methods	Quantitative methods
Student questionnaires	Recording computer equipment data
Teacher questionnaires	Assessing of essays
Taped interviews	Using scales of WISP
Descriptive assessment of essays	Assessing concept maps
Researcher observations	Counting the hypertext pathways
Conversations with teachers	(in the second extended study)
Classroom discourse analysis	

Design of the Pilot Study

The design of the pilot study included an initial open-ended questionnaire addressed to students and teachers to establish the perceived problems in scientific literacy. This was followed by the development of the scientific literacy development plan, SLDP, which was the subject of the pilot study. The research design for the collection and analysis of quantitative data was a quasi-experimental design with selected experimental and control groups. The pilot study was meant to be more than a single case study but to remain small enough to be managed personally by the researcher. Four classes in three different schools were chosen for the experimental group and three classes from two different schools for the control group. This sample was not necessarily representative of the target population, namely the Year 11 physics students, but represented a range of students with high computer competence to novice computer users. The control group classes were selected to resemble as closely as possible the experimental group classes, but it was not possible for them to be subject to exactly the same conditions.

The quasi-experimental nature of the pilot study enabled a comparison to be made of performance over the same writing tasks in both the experimental and control groups. Collections of pre-treatment and post-treatment data were made in order to make comparative analyses. It was hoped from this design to establish whether any changes that occurred in the experimental group were different from changes that occurred in the control group, and whether the changes could be ascribed to the SLDP treatment. The researcher conducted all SLDP treatments and administered all pre-treatment and post-treatment writing tasks to the experimental and control groups. In this way the researcher could ensure that the same conditions applied to the administration of all writing tasks and also could act directly as an observer to gain information for the post-pilot study development and refinement of the SLDP.

To counteract at least one of the difficulties usually associated with quasi-experimental comparative studies, namely non-equivalence of the groups, it was planned to use an objective test for literacy which had previously established national norms: TORCH (Mossenson, Hill & Masters, 1987). In this way students with similar levels of literacy could be compared. A further difficulty sometimes associated with instrumental unreliability, was offset as much as possible here by adapting and using a current form of writing assessment: the Writing Based Literacy Assessment (WBLA) (SSABSA, 1990) as contained in Appendices 5.6a and 5.6b. The efficacy of these instruments was carefully monitored and reviewed after the results of the pilot study came to hand. A possible Hawthorne effect causing an apparent enhancement of experimental group results, was seen as a potential threat to the validity of any comparative judgements. However, since this was a pilot study primarily to test the components of the proposed SLDP, comparative judgements were made with caution as discussed in Chapter 5.

The qualitative data were collected by means of the open-ended questions asked of students and teachers after the trial of SLDP. The questionnaires including typical responses are contained in Appendix 5.7a and 5.7b. The trial results are reported in Chapter 5 and were used for developments and refinements for the first extended trial.

Design of the First Extended Study

After re-development and refinement of the SLDP, an extended study was planned. This study was a time-series design with repeated treatments of SLDP administered to a new experimental group. Similarly, a control group data collection was planned with similar but non-equivalent writing tasks. It was thought at this stage of the trialling to leave the assignment of writing tasks completely open to teachers regardless of topic and writing genre. (Later, this decision was found to result in tasks which were too open for reliable comparisons to be made between groups, as discussed later. Nevertheless, the wide range of scientific writing collected was valuable to ascertain the range of genres used.)

The sample was planned to be more representative of Year 11 physics students than was the case in the pilot study, by including schools across a broad range of socio-economic backgrounds and across a range of available computer facilities. Any possible Hawthorne effect for the experimental group was somewhat lessened by participating teachers being inducted to deliver and control the program, which meant that SLDP would be integrated into the course schedule and not be seen as something special for the experimental group. The role of the researcher would then become that of an observer.

The difficulties associated with repeated treatments, such as maturation effects, sample mortality, and statistical regression, were acknowledged and noted as much as was possible. For example, it was assumed that the maturation of both groups in terms of writing skills and physics knowledge would be approximately the same if the trial for both groups was conducted over the same duration at about the same time in the Year 11 classes. The sample mortality was beyond the control of the researcher and would need to be taken into account in the analysis of results. The repeated measures design takes into account effects of statistical regression, meaning that subjects who scored highest in pre-test were likely to score relatively lower on post-test and the converse case. To identify the range of literacy skills within groups, a scale of 'writing-in-science-potential' (WISP) was devised. This scale was constructed from sources external to the research project. The sources were the TORCH (Mossenson et al., 1987), the WBLA conducted by consensus of teachers at the school level, and the semester grades assigned in physics by the participating teachers.

The pilot study revealed a problem with assessment of the student writing pieces and a better scheme was devised for this study. This resulted in a more clearly defined assessment scheme called the Scientific Explanation Genre Assessment Scheme (SEGAS) (see Table 6.1). This assessment scheme could then be used as a basis for finding consensus between researcher and each participating teacher in the assessment of writing tasks. However, there were still problems with trying to achieve a quantitative consistency with results, mainly because of the non-equivalence of writing tasks and the sample mortality as discussed in Chapter 6. It was difficult to gain a collection of two pre-SLDP writing tasks and two corresponding post-SLDP writing tasks. The method for rectifying this was to narrow the writing task criteria and to extend the duration of the trial as discussed in Chapter 7.

For the collection of qualitative data, a teacher questionnaire and a student questionnaire form were administered. (Copies are included in Appendices 6.4 and 6.6.) These questionnaires contained both directed questions and open responses. The open response questions were necessary to find out how acceptable the program was to both the teachers and the students. The student questionnaires were anonymous to encourage honest responses. It was not possible to make the teacher questionnaires anonymous because the small number of teachers involved became personally known to the researcher. However, participating teachers were straightforward in their comments and as there was no personal gain for them in this project, their comments were assumed to be reliable.

Another form of qualitative data to be collected was the one-to-one taped interview between students and the researcher. An unstructured form of interview was used, as described by Cohen and Manion (1985), where the content, sequence and wording of questions were determined during the interview rather than before it. This was to elicit descriptive responses to questions which would then leave the researcher free to pursue interesting or unexpected issues if they arose. Transcripts then were made of some interviews to assist analysis. The purpose of the interview was to verify the findings of the student questionnaires in assessing how acceptable the SLDP was to the students and in particular, how comfortable they felt with the computer-assisted components of the program. This was partially to answer the second research question about the effectiveness of the program.

The qualitative results from questionnaires, interviews and conversations, were consistent with those from the pilot study and hence the research project proceeded, with modifications, to the next phase.

Design of the Second Extended Study

After further development and refinement of SLDP and the instrumentation for writing task assessment, a time-series design was employed in the second extended study, with greater control over some of the variables. For example, the participating teachers were supplied with a list of writing tasks that conformed to a single genre of scientific writing but still allowed application to a range of topics. Two writing tasks were assigned pre-SLDP and two writing tasks with SLDP. In this way it was anticipated that a better quantitative consistency could be achieved in the assessment of the writing pieces of both experimental and control groups. The sample selection was broadened further for better representativeness and to offset the likely effects of sample mortality.

Part of the problem of assessing the quantitative data that arose from the results of the first extended study was the difficulty of comparing results from students with a broader range of writing-in-science-potential (WISP) than was available on the three point scale of the first extended study. For example it was difficult to compare students with poor English language skills but good skills in composition and structuring of ideas with those who might have fluency in English language but inferior composition skills. To assist this analysis, the WISP scale was therefore expanded from a three point scale to a seven point scale using more division in the criteria from TORCH, WBLA and Physics semester grades as well as the inclusion of an English language skills component. This latter was achieved with using the semester grades from the students' English teachers to be part of the scale as discussed in Chapter 7 and illustrated in Table 7.1. The data collection then for this part of the research consisted of essays, concept maps and registration of hypertext pathways used in the HyperCard Pathways writing model. This allowed for reliable and valid analysis to be made of quantitative assessment as discussed in Chapter7.

During the course of the SLDP program with the experimental group, the researcher was either not present or assumed the role of an observer. This enabled participating teachers to be seen to be fully in control of the program as part of their own course schedule. The Hawthorne effect and its reverse, the John Henry effect, were counteracted in this study by the researcher visiting the control group classes after assessment of each writing task, and giving feedback and personal interviews in the same manner as was done with the experimental group classes. In this way the control group students were treated as if they were trialling something for the visiting researcher, namely the assessment of essays.

For the collection of qualitative data, a student questionnaire and a teacher questionnaire were again used. (Copies are included in Appendix 7.3a and 7.3b.) In addition, classroom interactions between teacher and students were tape recorded for discourse analysis purposes and compared with taped interactions between teachers and individual students at computer work stations. This was done using Malcolm's (1986) adaptation of the Hymes (1972) model of classroom interaction analysis (Appendix 7.5a and 7.5b). This enabled comparisons to be made between the discourse patterns within classroom contexts and within the computer work station contexts.

The quantitative and qualitative data from this second extended study were sufficient for detailed analysis to assess the general effectiveness of SLDP in answer to research question 3. Specific analysis in terms of the elements of the definition of scientific literacy, to answer research question 4, required a search for evidence of activating the cognitive processes, engaging in the discourse of science, using a form of language register of science, and communicating in the proposed pathways model of writing, for scientific literacy.

Combining Qualitative and Quantitative Methods

Combining the Results of Trialling SLDP

A combination of qualitative and quantitative data were used in the study for several reasons. Classroom research into the effectiveness of SLDP required a range of qualitative methods and data analysis, because the effectiveness of the program was bound up with how it would be received by the students and teachers, called here 'acceptableness'. The acceptableness factor could be assessed only by asking the students and teachers how they felt about using SLDP, and qualitative methods such as questionnaires, interviews and observations yielded data for this purpose.

In addition, assessment of the effectiveness of the program needed to be related to the types of assessment of writing tasks currently employed by the examining body, namely the Senior Secondary Assessment Board of South Australia. The method employed for WBLA is a consensus method by a group of trained teachers. The assessment is either 'satisfactory performance' or 'requirements not met'.

Also, teachers normally assess physics by assigning marks out of 16 (to correspond with the public examination marks in physics essays), or grades A to D. This form of quantitative assessment in the feedback during this project was regarded as crucial by students and teachers alike, and hence this research project needed to provide a comparable quantitative assessment to maintain credibility with the participating students and teachers.

By combining the qualitative and the quantitative data, the effectiveness of SLDP could be determined. The legitimacy of combining methods has been established in the literature even though there is some debate whether this should be done. This debate is briefly described here.

The Debate in the Literature

Much debate has occurred in the literature between quantitative and qualitative research paradigms as described by Abbott-Chapman (1993), Fraser and Tobin (1991), and Gage (1989). In some cases, the paradigms were seen to be incompatible (Guba, 1978; Firestone, 1987; Smith & Heshusius, 1986). However, other researchers (Jaeger, 1988; Weiss, 1991) see methods that employ a combination of paradigms to be useful.

Nolan and Short also (1985) favoured a combination of paradigms because each was equipped to answer some questions within the research project and not others. Mathison (1988) and Denzin (1988) recommended a combination of qualitative and quantitative methods for educational research. Abbott-Chapman (1993) went further by saying that not all research which is statistically significant is necessarily socially or educationally significant. The implication is that the reverse is also true. This, according to Abbott-Chapman, "underlies the need for a complementarity of methodological approaches" (p. 61).

The qualitative approach is appropriate to educational research, according to Abbott-Chapman (1993), because it seeks to find the multiple ways in which people understand their world and react to it. Abbott-Chapman saw the role of quantitative research in education as providing a valuable corrective to qualitative interpretations "which lean too heavily upon a particular normative framework [of either the researchers or the commissioning/finding body]" (p. 59).

In some research studies the results from the two paradigms of research tended to support each other, such as for example, the studies cited in Bryman (1988). In other instances, the results from the two paradigms contradicted each other (Denzin, 1978). However, the National Board of Employment, Education and Training (1992), in its seminal work on the strategic review of educational research in Australia, stressed the need for goal oriented-research so that more attention be paid to the appropriateness of methods to suit research goals and contexts. Appropriateness could be served by a combination of methodologies. The report of the National Board of Employment, Education and Training (1992) stated:

> In fact, it is by no means impossible to combine different approaches in one study, thus confirming that there is more common ground than is often supposed and suggesting that the positions taken in the methodological controversies may be overstated. (p. 59)

For this reason, the National Board of Employment, Education and Training (1992) recommended that collaborative attention of researchers from a variety of disciplinary backgrounds and theoretical perspectives was necessary. Whatever the outcome of the debate in the literature might be, there is sufficient authority to use a combination of methods in this research project.

Overview of Data Analysis

The variety of qualitative and quantitative data collected to answer the research questions required different kinds of data analyses. In this section, the approaches are described: first, the quantitative evidence for change in overall writing performance, the change within level of WISP, and the change in concept map performance; then second, the qualitative evidence from teacher and student questionnaires, interviews and conversations, classroom discourse, and researcher observations.

Analysis of Change in Overall Writing Performance

The quantitative measure of overall writing performance was obtained from the same assessment instrument, the SEGAS, for each of four pieces of extended writing in the same genre by students in the experimental and control groups. The overall change from the first and second writing tasks (pre-SLDP for the experimental group) to the third and fourth writing tasks (post-SLDP for the experimental group) was analysed by using a multivariate analysis of variance (MANOVA) for both experimental and control groups. This was used to detect any differences between changes in performance of the experimental and control groups. For each group, the MANOVA analysis was used to establish the statistical significance of the change between each of the writing tasks. Use of the contrast-difference statistics (the reverse Helmert measure) made this possible.

Trials with experimental and control groups in the second extended study were conducted under similar circumstances, so it was unlikely that other factors such as history, maturation or statistical regression would affect the overall possible difference in writing performance. These circumstances were also similar to normal practice in mainstream schools across the State. In other words they were conducted in normal lesson times, within common course schedules and subject to the same constraints and unexpected difficulties that occur in most schools, such as lesson times being changed or cancelled, computer facilities becoming unavailable or teachers' priorities changing. Therefore the results of change in overall performance in scientific writing over four pieces of extended writing over two Year 11 semesters, should be applicable to a wide range of mainstream schools in South Australia.

Analysis of Change According to WISP

The scale of students' writing-in-science-potential (WISP) made it possible to detect whether changes in writing performance were different for students with high WISP compared with those with low WISP. The results allowed statements to be made about the applicability or otherwise of

SLDP for students with different abilities. An additional trial of SLDP with a sample of students known to be at low WISP because of inadequate language skills, such as the classes of New Arrivals Students, was conducted with SLDP in the second extended study. These results added to the assessment of the effectiveness of SLDP among students with different WISP, and allowed examination of the applicability of SLDP to a wide range of student ability. This testing over an ability range again makes the study relevant to mainstream schools in South Australia.

Analysis of the Concept Maps

Analysis of concept maps produced during SLDP trials was achieved with an existing quantitative scoring scheme for concept mapping (see Appendix 5.3). It was adapted to measure the degree to which concepts and relational statements were used by the students. This allowed examination of how students constructed concept maps compared with their composition techniques for extended writing. The use of concepts, the hierarchical pattern of linking concepts, the relational statements used in the links, the degree of sub-summation of concepts and integration of others into more general features could all be assessed quantitatively. This allowed comparisons to be made between concept mapping performance and writing performance. This comparison was best done in WISP levels as these levels allowed for similar abilities in English fluency or physics knowledge to be compared.

It was possible from an examination of concept maps and corresponding essays to deduce certain text processing strategies that were employed by students. The concept map assisted the researcher and teachers in identifying these strategies. It was also interesting to compare the amount of text processing strategies used by students with accompanying concept maps (the experimental group) and those done without concept maps (control group) as reported in Chapter 7.

A comparison was also made between the first post-SLDP concept map and the second post-SLDP concept map to test for development here. This was another measure that could be used for assessing the effectiveness of SLDP.

Analysis HyperCard Pathways Used

The hypertext pathways were the individual pathways that students used in completing the piece of extended writing. Students were asked to record the pathways they chose as they worked through each HCP module in the completion of their writing task. A simple count of pathways chosen in moving back and forth between each part of the module was possible. This indicated how composition, structuring of ideas and use of concepts were used in the writing exercise. Comparisons could also be made between the use of pathways and the overall writing performance. The results of these analyses are contained in Chapter 7.

Teacher and Student Questionnaires

Participating teachers and students in each phase of the research project were asked to write answers to questions concerning the effectiveness of SLDP for them personally and results are reported in Chapters 5, 6 and 7. Interpretation of the results indicated the degree of acceptableness of SLDP by teachers and students. This was an important component in assessing the overall effectiveness of SLDP. Differences in student responses compared with teacher responses to similar questions, were analysed for confirmatory or contradictory comments. Mathison (1988) indicated that within triangulation of qualitative methods, some research outcomes could be inconsistent and contradictory. These were not necessarily denials of the research assertions but challenges to construct alternative propositions for fuller explanation. Mathison (1988) stated:

> The value of triangulation lies in providing evidence such that the researcher can construct explanations of the social phenomena from which they arise. (p. 15)

In the case of this research for example, some instances of inconsistencies occurred when some students said they liked the technique, but wrote the essay before they constructed the concept map; some teachers said they liked the technique but then did not use it again after the period of the trial; the concentration on one genre of scientific writing could possibly lead to the view that this was the only genre of value. It was necessary therefore for the researcher to be vigilant to the presence of inconsistencies in the results that may need further investigation or explanation.

Interviews and Conversations

Transcripts of taped interviews were analysed to indicate which components of the SLDP program were less effective than other components. The purpose was to identify components that required redevelopment and refinement between each successive phase of trialling.

Casual conversations with participating teachers and students were another source of detecting difficulties in using the components of SLDP, and to gauge how acceptable the program was to teachers and students. These conversations, by their nature, could not be formally transcribed, but attentive listening on the part of the researcher gave information about the general progress of development and refinement of SLDP and to its eventual effectiveness.

Analysis of Classroom Discourse

The analysis of classroom discourse was done by two established methods: that of Malcolm, (1986) and that of Lemke (1990), to indicate differences in regular classroom discourse compared with the discourse at computer work stations. The model of discourse analysis of Malcolm (1986) utilised the speech acts within the framework of language functions of Halliday (1978), the ideational, the interpersonal, and the textual functions. These language functions are defined as follows:

> The ideational function is to organise the speaker's or writer's experience of the real or imaginary world, i.e. language refers to real or imagined persons, things, actions, events, states, etc. The interpersonal function is to indicate, establish, or maintain social relationships between people. It includes forms of address, speech function, modality, etc. The textual function is to create written or spoken text which cohere within themselves and which fit the particular situation in which they are used. (Richards et al., 1985, p. 116).

Examples of regular classroom discourse were analysed by using the criteria of Malcolm (1986) for categorising dialogue initiated by teachers on one hand and students on the other, according to language functions (ideational, interpersonal, and textual). The method of Lemke (1990) was used to identify the dialogue strategies for setting thematic patterns. The dialogue strategies assessed were the teacher question and answer (TQA) series; the teacher question, elaboration and modification (TQE&M) series; and the joint construction (JC) series. Analysis of the dialogue in classroom discourse and of the dialogue at the computer work stations, enabled the differences to be assessed. This yielded an indication of the effectiveness of the SLDP. These results of these analyses are contained in Chapter 7 and Appendices 7.4a and 7.4b.

Researcher Observation

Observation was perhaps the most valuable of all qualitative methods. The researcher was able to observe the difficulties experienced by students with computer manipulation, the choices of pathways for construction of concept maps, the use of contextual readings and other parts of the modules, all of which assisted in the development and refinement of the SLDP.

According to the literature, the use of computers for learning presents problems for some students (and teachers). The factors affecting computer anxiety were reported by Hayek and Stephens (1989), Marcoulides and Wang (1990) reported on a cross-cultural comparison of computer anxiety in college students, and Silver and Repa (1993) investigated the effect of word processing on the quality of writing and self-esteem of secondary ESL students. The results of these studies indicated that certain students have computer anxiety that militates against learning. Therefore part of the role of the researcher was to be attentive to the fears, needs and anxieties of certain students during the course of SLDP. This meant that the role of the researcher varies during the pilot study, the first extended study, and the second extended study. On the four point scale of Merriam (1988), the possible positions for observer research are complete participant, participant with some observation, observer with some intervention, and as complete observer. In the pilot study, the researcher was a complete participant in teaching the SLDP lessons, administering the writing tasks, assisting students in the construction of concept maps and writing compositions. In the extended studies the role shifted much more to that of observer with some intervention where necessary. Teachers conducted the SLDP themselves with assistance from the Teachers' Manual and lesson pack. In the second extended study, the lessons were often conducted without the presence of the researcher. At the completed stage of development of SLDP it is possible for further research to be conducted by a person in the role as complete observer.

After observing classroom lessons in which the teaching of elementary sentence construction, paragraph writing and working in scientific genres was done, the researcher could see the level of difficulty experienced by students, and the level of knowledge of English grammar conventions of the teacher. This was important, considering that science teachers normally have little background training in English language teaching. This allowed the researcher to investigate the need by teachers for detailed lesson plans and overhead transparencies in the form of lesson packs for each topic of the course. In some cases it seemed that teachers needed these supporting materials and in other cases the materials were not so necessary. However, it seemed important to supply all participating teachers with a Teacher's Manual and lesson pack to enable them to choose how much of the materials they would use. This avoided potential embarrassment to teachers who had limited knowledge of English language grammar, conventions of genre writing and the use of the language register of science.

Limitations and Assumptions of the Research Design

The study of the components and effectiveness of SLDP has an importance wider than just a single case study. If the trialling can be shown to be valid, reliable and ethical, it will have meaning and applicability for others in the educational world. Different paradigms of research make different assumptions about reality, different terminologies and different designs, according to Lincoln and Guba (1985), for example, who proposed using the terms truth value for internal validity, transferability for external validity, and consistency for reliability. However, according to Merriam (1988) the basic question remains the same: "To what extent can the researcher trust the findings of qualitative research?" (p. 170). To this end, the discussion concerning validity, reliability, and ethical conduct uses the conventional terms, as were used by Merriam (1988).

Internal Validity

Internal validity, according to Merriam (1988), deals with the question of how one's findings match reality:

> One of the assumptions underlying qualitative research is that reality is holistic, multidimensional, ever-changing; it is not a single fixed objective phenomenon waiting to be discovered, observed, and measured. (p. 167)

This description suitably fits the most basic assumption underlying this investigation into scientific literacy, that is, that scientific literacy is a human activity. As such it is different for every individual. No attempt was made in this research to measure an individual's scientific literacy on some objective or absolute scale. Rather, the investigation was concerned with how to improve the scientific literacy of a representative sample of Year 11 physics students. The comparison was made in a quasi-experimental manner with an experimental group who, like the control group, were themselves subject to on-going change. The five basic strategies of Merriam (1988) were employed to ensure that internal validity was effected.

Triangulation. The research design at each phase of the research employed triangulation of data collection and analysis to find answers to the second research question, namely, the required components of SLDP. The third question about the SLDP effectiveness relied on analysis of both quantitative and qualitative data. The fourth research question was answered mainly by using several sources of data to establish the match between performance with concept maps, hypertext pathways, use of dialogue, and use of the language register of science, with the elements of the definition of scientific literacy.

Member checks. This means taking the data and interptretations back to the people from whom they were derived and asking them if the results are plausible (Merriam, 1988). This was done in this research by producing interim reports at the end of each phase of the research, disseminating them to the participating teachers and school authorities, and asking for their comments. This allowed modifications to be made as the research progressed and which fulfilled the suggestion of Guba and Lincoln (1981) that review and reflexivity should be done continuously.

Long-term observation. This was achieved by using a number of the same schools and participating teachers in each phase of the research. Although the number of participants in each phase of the research was increased and the range of participants broadened, there were a number of teachers who continued from the previous phase. These teachers could compare the implementation and results of SLDP from one phase to the next.

Peer examination. This was achieved by referring the findings of each phase of the research to the participating teachers, colleagues and thesis supervisors (named in the Acknowledgments). This provided another perspective on the reflections and a reasonably objective assessment of the progress of the research.

Participatory action. This was achieved through input of the various participating teachers. However, the task of linking all sections of the research from definition, data collection, data analysis, to reporting, was the work of one researcher. A team approach to this project would possibly yield a different scientific literacy development plan and perhaps different modes of assessment of its effectiveness. However, this SLDP was trialled with enough participatory action to become well known in the teaching fraternity, which resulted in requests for the use of the program beyond this research project.

These strategies were incorporated into the research design and assisted with establishing internal validity, that is, the trials were in fact testing the propositions of the research questions. Specific threats to internal validity such as history, maturation, statistical regression, and instrumentation were discussed in the research design phases. The sample mortality was an uncontrollable factor and was a principal focus for improvement of the design for the second extended study, in which tasks were more clearly defined and consistency of data collection given a higher priority than was the case in the first extended study.

External Validity

External validity, according to the literature, is subject to the limitations and assumptions that arise from the representativeness of the sample and from the research design, as discussed in the following paragraphs.

One of the most common forms of sampling for qualitative studies, according to Merriam (1988), is the purposive or criterion based sampling, which is in contrast to statistical random sampling where the primary concern is for representativeness of the population from which the sample is being drawn. The characteristics of purposive sampling here, were related to the willingness of schools to participate, the socio-economic school background and to pre-determined criteria concerning equipment.

Willingness of schools. Because the purpose of the sample selection was to illustrate the use and effectiveness of the SLDP to the wider educational community in South Australia, it was necessary in the pilot study to select schools where concerns and circumstances were similar to those of the wider community. The method chosen for the pilot study was to select certain schools known for their suitable computer equipment and willingness to be involved in classroom research. After the pilot study, all schools in South Australia were informed of the project through the South Australian Science Teachers network and then, as a result of the interest shown, a workshop was conducted for the interested teachers. This resulted in new schools being added for the first extended study. It was also anticipated that other teachers would hear of the project by word of mouth, and respond with interest. This did occur, and resulted in the addition of new schools for the second extended study. The control schools were selected in each phase of the research because of their similarity in socio-economic background to the experimental schools.

Socio-economic background. Background data of a general nature about socio-economic environments were found from the Australian Bureau of Statistics (Adelaide: A Social Map, ABS 1986), the Educational Resources Index (Department of Employment, Education and Training, 1991), and from general school information in school year books and brochures. This resulted, by the time of the second extended study, in a sample of experimental and control schools with the following backgrounds: low to middle socio-economic background government schools and non-government schools. These included co-educational, and single-sex girls' and boys' schools, mainstream schools and a specialist re-entry for adult learners school. This ensured a broad range of schools in the samples.

Pre-determined equipment criteria. The pre-determined criteria for the experimental schools related to suitable equipment being available. Only schools with *Macintosh* computer equipment could participate as part of the experimental group because the HCP modules were written in the HyperCard software package text which was not transferable to other computer models. The technical requirements were:

* the HyperCard version 2.0 or 2.1 was required;

* size of *RAM* to be 2 *megabyte* to enable the use of all tools required in the HCP modules;

* adequate storage memory on the *network* was required if students were to work in work stations folders; alternatively, personal 720 *kilobyte discs* for each student was necessary;

* *digicard* or *ethernet* work station linking was required for quick processing time;

* an adequate number of machines for the number of students in the classes.

If this equipment were not available, there were some limited alternatives. For example, students without access to this equipment could be transferred, with appropriate authorisations, to a neighbouring school with the equipment. Another alternative was to bring computers to the school for a short period. These alternatives were used by one school as described in Chapter 5.

As mentioned earlier, the representativeness of the samples was limited by the willingness of schools to be involved, the range of socio-economic backgrounds, and the pre-determined equipment criteria. For the study to have external validity, the assumption was made that these schools would be broadly representative of the majority of secondary schools in South Australia. This was a reasonable assumption in that the six schools from which the experimental group was formed and the five schools from which the control group was formed were drawn from different socio-economic areas of Adelaide as determined by population distributions contained in the Adelaide: Social Atlas (Bureau of Statistics, 1988).

Limitations of the Research Design

Since the research design was principally that of a qualitative study, the assumptions of external validity are discussed according to the limitations of this paradigm. According to Merriam (1988) there are four positions that a researcher can take in regard to external validity. There is the traditional position that external validity is assured through setting the a priori conditions such as equivalence of the trial sample to the target population through strict measures of control of sample size, random sampling and other such methods. The second position is that of Cronbach's (quoted in Merriam, 1988) replacement of generalisability in social science research, with what is termed 'working hypotheses' (p. 174). This notion required that the researcher "describe and interpret the effect anew in each locale, perhaps taking into account factors unique to that locale or series of events." (p. 174). The third position concerning generalisability, is that it lies in attending to the particular concrete universals (Merriam, 1988), not in attending to the search for abstract universals. This is called the "naturalistic generalisation" by Merriam (1988, p. 177). A fourth way to view external validity is that of reader or user-generalisability, which leaves the extent of applicability of a study's findings to the user in any particular situation.

It is this fourth way of understanding generalisability that best suited this research project. It was not claimed that SLDP incorporated abstract universals about scientific literacy, or that the components used in this program were the only ones for all situations. However, it was assumed that SLDP provided more than working hypotheses, because the definition of scientific literacy was derived from a synthesis of theories concerned with the cognitive processes of the mind, the discourse of science, the use of a language register of science and cognitive writing processes. The SLDP with its proposed HyperCard Pathways model for writing in science was also more than a naturalistic generalisation. The triangulation of data and collection methods ensured a degree of predicability about results for other users in similar situations.

Thus, SLDP is assumed to have user generalisability. The purpose of developing the SLDP was to provide a technique that could be fully integrated into a teacher's course schedule. The SLDP was not meant to be a mini-course in itself, a 'quick-fix' to literacy problems, but a series of components that could be used at the choice of the teacher. The components need not be used sequentially because they were they designed to be used with any topic in the course schedule. The limitation only was the number of topic-specific HCP modules. However, within any one HCP module there was the facility for teachers to adapt the techniques, change the content, or assign a different writing task to students. In addition, the Teachers' Manual which accompanies SLDP (Appendix 6.1) describes how a teacher can make a new topic module.

A summary of three ways to improve external validity in qualitative studies is supplied by Merriam (1988): providing a rich description, establishing typicality; conducting cross-site analyses. These were applied in this research project as described in the following paragraphs.

Providing a rich description. Merriam (1988) cites Lincoln and Guba (1985) in requiring a rich description "so that anyone else interested in transferability has a base of information appropriate to the judgement" (Merriam, 1988, p. 177). This has been provided by describing each phase of the study separately (Chapter 5, 6, 7), and with the provision of a large body of appendices (40 items) in this thesis (in Volume 2).

Establishing typicality. This enables readers to make comparisons between what is reported and their own situations. This is done in the following chapters by describing the backgrounds of the schools and teachers involved in this research. Each phase of the study provided typical classes in which the trials were conducted. The difficulties encountered in the assignment of definite writing tasks, in the collection of data, and in the assessment of writing, are described in each of the phases of the project, with the assumption, that other teachers encountering similar problems would be assisted by the strategies reported here for enhancing scientific literacy.

Conducting cross-site analyses. Data are gathered from cross-sites to learn as much as possible about the contextual variables that might have a bearing on the case (Merriam, 1988). This was done in each phase of the research as described in Chapters 5, 6, and 7.

The limitations then to external validity may be found in the nature of the representativeness of the sample of experimental and control groups for each phase of the research.

Reliability

Reliability refers to the extent to which the research findings can be replicated (Merriam, 1988). In qualitative research, there is no bench-mark by which repeated measures can be taken and reliability with statistical procedures established. Rather it is in the nature of interpretation of the findings and whether a repetition of the research with similar samples would establish the same findings. Given that it would be impossible to repeat the study with exactly the same samples, the assumption made here is that the findings would at least be consistent. This is a reasonable assumption given that the finding of effectiveness of SLDP was a relative comparison between experimental and control groups. The relativeness may vary according to the nature of any experimental and control groups but this study has established the procedures for SLDP by using well developed HCP modules that can be replicated. This more liberal sense of reliability is called dependability or consistency by Lincoln and Guba (1985) and by Merriam (1988). The steps to be used to ensure dependability after Merriam (1988), are discussed in the following paragraphs.

Researcher's position. The role of the researcher in this study was that of developer, presenter, and observer in the pilot study. In the first and second extended studies, the role became progressively that of an observer, with intervention only when necessary. The researcher also provided feedback to all students from whom pieces of writing were collected. For replication of the study, a future researcher would be guided by the protocols contained in the appendices and by the instrumentation used.

Instrumentation. The assessment schemes of the writing tasks and the concept maps have been independently shown to be consistent. The discourse analysis techniques, have also been used independently (Malcolm, 1986). The WISP categories were set from independent sources.

Triangulation. By using multiple methods of data collection and analysis, reliability as well as internal validity was strengthened according to the theory of Merriam (1988). Quantitative data analysis was used to support the qualitative data analysis.

Audit trail. This requires that researchers present their methods in such detail "that other researchers can use the original report as an operational manual by which to replicate the study" (Goetz & Le Compte,1984, p. 216). This is achieved here with full documentation and inclusion of extensive appendices.

In summary, precautions were taken to ensure a reasonable degree of reliability in this research, and hence the results are claimed to be reliable within the limits of described above.

Ethical Research Conduct

There are different ethical concerns for each research paradigm. Cassell (quoted in Merriam, 1988) proposed a continuum of risk from biomedical experimentation to participant observation studies. In the case of qualitative studies, Merriam (1988) stated that it was difficult to assess when, for example, questioning a respondent became coercive, or when familiarity induced unwitting responses, or when the findings might be used to the detriment of those involved. On the other hand, there was the possibility of the report being so general that it hindered the reader from distinguishing between data recorded and the researcher's own interpretations.

In this research safeguards were employed to provide a balance between these concerns: the preservation of anonymity, member checks on the reporting of actual transcripts, and the termination of the research process.

Anonymity. This was preserved by reporting all teachers' names by pseudonyms, all schools by alphabet characters, all classes by number, and students by a single initial. The purpose of collecting the students' papers was known to them beforehand. The papers were photocopied and returned to the students, with assurances that the photocopies were used only for this research. The results of objective test TORCH (Mossenson et al., 1991) were given to the participating teachers in a descriptive form only, rather than numerical scores of students. To guarantee mutual protection for the researcher and participants, letters of permission were obtained from all school principals (Appendix 5.5a). In the case of South Australian Education Department schools, the Agreement for Privacy provisions (Appendix 5.5b) was signed by the researcher.

Member checks. Interim reports for each phase of the research were prepared and disseminated to participating teachers and school authorities. In this way, the use of direct quotations from teacher and student questionnaires, transcripts from interviews and class dialogue were tested for accuracy before inclusion in the thesis.

The termination process. The process of terminating the project at the end of its project time or when schools drop out of the project, was made clear. Teachers' reasons for dropping out were respected. Such reasons were given as: time constraints on the teacher making it impossible to fit in the SLDP, staff changes or re-allocation of teaching duties, perceived unsuitability of SLDP for the students, access to computer equipment being terminated due to changes in time table or rescheduling of the computer room facilities. The process of termination in these cases was characterised by openness between the researcher and teacher about the reasons. Feedback was given to students in a supportive manner to their general learning process. Appropriate thanks and acknowledgments were made to the school.

With these strategies, the researcher attempted to be conscious of the ethical issues in all stages of the research process, from the beginning, to the reporting and disseminating of the findings.

Chapter Summary

The design of this research project was a combination of methods from both the qualitative and quantitative paradigms. The research design meant that quantitative and qualitative data were collected throughout the three phases of the research. The quantitative data were: assessment scores of student writing tasks, concept maps and construction pathways, and WISP levels from independent sources. A quasi-experimental design using a non-equivalent control groups was used for the quantitative aspects of the research. The collection of qualitative data was in the form of questionnaires, transcripts of interviews, classroom discourse analysis and researcher observations. The qualitative data were analysed as statements and descriptions relating to the subjects' personal experience of the program. The analysis of the data and the conclusions drawn were guided by means of triangulation of both the quantitative and qualitative findings. Recommended strategies to ensure validity, reliability, and ethical constraints were observed throughout the research.

CHAPTER 5
DEVELOPMENT of SLDP AND PILOT STUDY

Introduction

This chapter describes the response to the second research question concerning the construction and trialling of SLDP and its components. The first step was to conduct pre-SLDP investigations into students' commitment to reading and writing in general, and to ascertain the readability and text style of a range of scientific reading resources available to students. The results of the questionnaire and the reading resources survey are described in the first section of this chapter. Using these findings and information from the literature and literacy experts, the components of SLDP were determined to be language acquisition, concept mapping, constructive dialogue, and writing activities. The SLDP program was developed as a computer-assisted model for extended writing and a schedule for implementation in classrooms was planned. The next section of the chapter describes the pilot study for trialling the SLDP and the trial results. The chapter concludes with a discussion of the recommendations for further development and refinement of SLDP in preparation for an extended trial.

The Pre-SLDP Investigations

The basis for the design of the student questionnaire was the assessment framework developed by the South Australian Assessment of Writing and Reading In-service Teacher Education project team (Education Department of South Australia, 1991). The framework included broad criteria for assessment of Concepts, Attitudes, Aspects, Strategies and Range of students' literacy (CASSR). These assessment criteria were concerned with students' commitment to reading and writing and were adapted in this survey to gauge student attitudes towards writing and reading in science compared with writing and reading in other subjects. The questionnaire and a typical response is contained in Appendix 5.1.

The Student Questionnaire

The questionnaire was designed to produce information about the commitment to reading and writing activities in physics compared with commitment to activities in other subjects. Four classes of students from three schools were surveyed, giving a combined total of 64 students. Of the 64 physics students, 18 studied physics and English, 9 studied biology and English, and two students studied all three subjects at the public examination level (Year 12). These three subjects were chosen for comparison because each required extended writing in the public examination. The questionnaire asked students to rate themselves in physics, English and biology (where applicable) from 0 (low) to 3 (high) for each of the CASSR assessment criteria. The criteria which are listed in Table 5.1, questioned students' willingness to write drafts, assume responsibility, make changes, ask for help, give priority to ideas, share and discuss, be critically reflective. The results were converted to decimal means from 0 (minimum) to 1 (maximum) and are reported in Table 5.1.

Commitment to Writing in Science

The results indicated that commitment to writing in physics lagged behind that of English and marginally behind that of biology, with the exception of the criterion 'giving priority to the larger concerns of ideas'. The widest discrepancies occurred with drafting, making changes and being critically reflective, as shown in Table 5.1. This low commitment to writing is consistent with the poor performance of physics students in public examination extended writing questions compared with performance in other questions as reported in Chapter 1. Concept mapping as part of the new model for scientific writing, builds onto the one strength of extended writing in physics namely that priority is given to the larger concerns of ideas. Thus concept mapping was seen as integral to SLDP.

Table 5.1
Comparison of Commitment to Writing in Three Subjects

CASSR criteria for commitment to writing	English	Biology	Physics
* To write drafts and then re-write a final copy	.84	.58	.55
* To assume responsibility for meeting deadlines and making self-corrections	.88	.61	.75
* To make changes by exploring alternative beginnings and endings	.76	.61	.50
* To ask for help and feedback and accept changes	.75	.78	.66
* To give larger concerns of ideas and information priority over spelling and grammar	.73	.64	.78
* To ignore distractions and stay on task when working alone or with others	.68	.61	.50
* To share your writing with others, discuss insights, accept advice and give suggestions to others	.62	.55	.52
* To be critically reflective and use your past experiences to shape future writing	.85	.61	.63
* Overall commitment to writing	.76	.62	.61

To the question in the questionnaire (Appendix 5.1) concerning preference for writing an extended piece in the three subjects, 14 of the 18 students who studied both physics and English chose English, that is 78%. Seven of the nine students who studied both biology and physics chose biology, also 78%. Of the two students who studied all three subjects, one chose English and the other biology. Thus six students out of 27 preferred extended writing in physics to extended writing in biology or English. This indicates the low preference in general accorded to writing in physics and the reasons given by students were seen to be important for the initial development of SLDP. The reasons given by the few students who chose physics as their preferred subject for extended writing were informative to the development of SLDP as well. Some typical responses of those who preferred extended writing in each subject respectively were as follows.

Preferring English. *I have never been able to grasp the concept of physics essays. Essays in English I have come to do really well.*
English, because they allow for creative use of language, descriptions, etc., even an analysis of novels, whereas physics is all factual.
English, because I'm a very literate person and I write with very complex language. I can't do that in physics essays.
English, because there is room for my own interpretation and there is not right or wrong, whereas in physics there is no room for individual interpretation sometimes, it is either right or wrong.

Preferring Biology. *The work is more everyday world. You can relate to the work more easily since biology has plenty to do with human physiology.*
Biology. They are the most comfortable combination of facts, ideas, and speculation.
Biology. Each essay gives you a large range to write on. Its not so specific.
Biology. because English essays are specific to several texts and requires companions. Biology essays are enjoyable to write. I think its because I like biology better as a subject.

Preferring Physics. *They are very theoretical, logical essays. In English, it is open to interpretation, there is no right or wrong, so I find English essays more difficult.*
Physics, because in physics you explain facts and don't have any trouble in expressing myself. In English you account for content and style whereas in physics its more like a review or summary.
Physics. I find it to be a lot more challenging and a lot more interesting.

These reasons expressed by the students indicate that they perceived the logical flow of the essay to be important in physics (a perception supported by literacy experts) and therefore instruction in the logical connectives as described by Gardner (1978) was taken as being essential to the SLDP program.

Responses to other questions in the questionnaire of Appendix 5.1, indicated the need for an essay writing strategy to lessen students' aversion to extended writing. To the hypothetical question asking if an essay question should be brought into the chemistry public examination, 43 of the physics students who studied chemistry answered as follows: 40 emphatically said 'no' (93%) and three 'yes'. The reasons given were as follows:

No I don't believe there are topics in chemistry which could be suitable for an essay.

No. It much harder to answer a question completely because an essay requires a lot of information in logical order.

No, because I would find it hard to explain the basics concepts in chemistry.

No, because I'm not good enough with word for writing.

Yes, to break up the calculations of the exam.

Yes. An essay would show the student real knowledge and understanding of the concepts involved.

It is the intention of developing SLDP to make it applicable to the other senior secondary science subjects such as chemistry and biology.

Commitment to Reading in Science

The same student questionnaire (Appendix 5.1) included questions about student commitment to reading. The CASSR assessment criteria for student commitment to reading are listed in Table 5.2 and refer to students' willingness to choose their own resources, assume responsibility, use dictionaries, ask for help, use the library, share and discuss, be critically reflective, and take risks. Students were asked to rate their own commitment to each criterion on the same scale as previously used for writing. The decimal means, reported in Table 5.2, show that commitment to reading in physics is similar to the result of commitment to writing, namely a lag in physics.

Table 5.2
Comparison of Commitment to Reading in Three Subjects

CASSR criteria for commitment to reading:	English	Biology	Physics
* To choose books and other reading matter beside the textbook	.71	.48	.53
* To assume responsibility for choosing reading matter in this subject	.62	.70	.53
* To use a dictionary, index or glossary to find the meaning of new words	.84	.59	.60
* To ask for help and advice from peers, teacher, librarian	.70	.59	.61
* To find books in the library interesting and helpful	.60	.63	.44
* To ignore distractions and stay on task when working alone or with others	.65	.59	.57
* To share your writing with others, discuss insights, opinions and interpretations	.62	.56	.54
* To be critically reflective and use own knowledge and experiences to compare text	.94	.48	.49
* Overall commitment to reading	.71	.58	.54

The Survey of Reading Resources

The results of the post SLDP student questionnaire with 91 Year 11 students (Appendix 5.7a), regarding the preference for reading material used by physics students, are shown in Table 5.3. The results indicate that physics students generally do not use reference material outside their own course texts. Various reasons for this were given, including the readability level of some science reference material, and the narrow range of writing being set by teachers which did not demand a wide range of reading reference material. Conversations by the researcher with teachers revealed that their priorities lay with covering the syllabus content expected by their students and satisfying the range of assessment tasks required by SSABSA, before class time would be given to scientific literacy activities such as reading science magazines.

Table 5.3
Students' Use of Reading Resources other than Textbook

Resources	Decimal proportion of student preference		
	Little use	Some use	Much use
School library	.35	.60	.05
Public library	.47	.45	.08
Science magazines	.64	.31	.05
Newspapers	.57	.39	.04
TV: "Beyond 2000"	.34	.48	.18
TV: "Quantum"	.72	.21	.07

Samples of reading resources was collected to ascertain the readability levels and the text style of scientific magazines and standard physics textbooks. The results are described in the following paragraphs regarding readability and text style.

Readability

Readability depends on a number of factors such as legibility, interest, and text style (Anderson, Durston, & Poole, 1969). A number of readability formulas such as Flesch Reading Ease (Anderson et al., 1969), Flesch-Kincaid score and the Gunning Fog Index (Pfaffenberger, 1992), Fry Scale (Thelan, 1984) and others have been developed and applied to a large range of reading materials. These formulas provide a scale of comparison between various reading resources and are used here to compare the readability of science text books and magazine materials.

The table of comparison of readability in Table 5.4 was calculated by using the document statistics facility in the *Microsoft Word 5.1* computer manual (Pfaffenberger, 1992). The physics texts surveyed were Conceptual Physics, Hewitt (1987), Physics One, De Jong, Armitage, Brown, Butler and

Hayes (1990), Physics: An Examination Course, Hanson (1986), Year11 Senior Physics, Moyle, Mole, Arthur and Millar (1986), Physics: principles and Problems, Murphy and Smoot (1982). Five samples of each reading resource were chosen at random, and passages of approximately 200 words scannned into the Word 5.1 computer document statistics facility. The criteria used in the document statistics facility were: sentences per paragraph, words per sentence, characters per word, percentage of passive sentences, the Flesch Reading ease score, the Flesch-Kincaid score and a composite measure called the Flesch grade level. The mean values for each of these criteria for each text are reported in Table 5.4. The texts are arranged in the table from left to right according to increasing Flesch grade level.

Table 5.4
Readability of Year 11 Physics Textbooks

Criteria	Murphy et al.	De Jong et al.	Moyle et al.	Hewitt	Hanson
Sentences per paragraph	2.2	3.7	2.8	3.3	2.2
Words per sentence	17.5	19.0	17.2	18.8	23.2
Characters per word	4.2	4.0	4.0	4.2	4.0
Passive sentences (%)	18.6	29.0	35.0	30.0	38.8
Flesch Reading Ease	61.7	56.6	53.4	54.8	53.0
Flesch-Kincaid score	8.7	9.8	9.9	10.0	11.2
Flesch grade level	9.23	10.7	11.4	11.5	11.8

The analysis of textbooks in Table 5.4 indicates a range of readability levels. The textbooks by De Jong et al. (1990) , Hewitt (1987) and Moyle et al. (1986) were used in the development of SLDP because of their median position within the Year 11 grade level, but not the textbooks by Hanson or Murphy et al.

Assessment frameworks for literacy such the CASSR criteria include students' resourcefulness in using sources other than textbooks so it was appropriate to investigate the readability of scientific magazines. A survey of a sample of science magazines was done using the same method as for the textbooks from three different editions of the magazines. The magazines were: New Scientist, Discover, Australian Newspaper Computer and Science Supplement, Popular Science, Ecos and Genesis. The mean values for each of the criteria for readability of each text are reported in Table 5.5. The magazines are arranged in the table from left to right according to increasing Flesch grade level. These results indicate that four of the five magazines had a readability level of more than two years above the Year 11 grade level and may explain the lack of use of such magazines by Year 11 students.

Table 5.5
Readability of a Sample of Science Magazines

Criteria	*Discover*	*Ecos*	*The Australian*	*Popular Science*	*New Scientist*	*Genesis*
Sentences/paragraph	2.6	2.0	2.0	2.0	1.7	1.5
Words per sentence	20.2	24.0	26.7	21.5	27.0	30.2
Characters per word	4.0	4.0	5.7	5.0	3.5	4.7
Passive sentences (%)	28.3	62	9.0	16.2	28.3	30.2
Flesch Reading Ease	57.0	52.9	43.0	36.2	40.8	37.5
Flesch-Kincaidscore	10.4	11.9	12.8	12.8	13.2	14.3
Flesch grade level	10.9	12.1	13.8	14.1	14.1	15.05

The ranking of readability and range of lexical difficulty corresponds in part to the scales of lexical difficulty for science magazines and journals compiled by Hayes (1992). The lexical difficulty scale is a logarithmic frequency curve for patterns of word usage and is calibrated from baseline data using word patterns from international English language newspapers. The problem identified by Hayes (1990) was the growing inaccessibility of science because of the escalating lexical difficulty of reading materials. Hayes's scale similarly indicated that all the science magazines except for Discover, were higher in lexical difficulty than physics textbooks, which is consistent with the findings of the survey here. Magazine material used for the contextual readings of SLDP was carefully selected and in most cases, extensively edited to lower readability levels.

Text Style

Text style is a contributing factor to the readability level and to the writing style adopted by students. Text style was classified by Strube (1984) (1989a, 1989b) to be formalist, catechetical or conversational in an investigation of the rise of the modern science textbook. Early textbooks employed a catechetical style, but this has given way to a formalist style for most textbooks and conversational style used in an enquiry approach. Strube (1989a) analysed style and norms of prose structure adopted in a wide range of physics textbooks and found that most adopted a formalist style with the following characteristics: distant authorial voice, concern for precision, limited contextualisation, limited syntax, the almost exclusive use of a linear rhetorical model of explanation, and a logical 'correct' method of scientific writing. In a further analysis of the presentation of energy and fields concepts in textbooks Strube (1988) states that:

> Their explanations generally take the from of inductivist/deductivist arguments. The role of the laboratory is reduced to a secondary verificationist one. And there is a great deal of logical reasoning from first principles. Their instructional language is a formal didactic one which mainly states conclusions rather than guides enquiry. (p. 369)

Strube's analysis (1989b) of the text style in ten commonly used physics and chemistry texts indicated that a number of prose structures were used: deductive from laboratory experiments deductive from real-life situations; narrative of enquiry (enquiry statements), rhetorical (statements made without justification), logical argument (statements derived from laws or principles). Strube (1989b) found that:

> The high number of unjustified statements and logical arguments supports the claim that all texts use formal language, and the low number of enquiry statements indicates that explanations are not elaborated or made explicit to the reader. (p. 201)

A preliminary survey of student writing collected from pre-SLDP physics writing assignments of one physics class indicated rhetorical characteristics and logical argument characteristics in student writing style similar to that of textbooks. This is shown in the following examples of student text in Table 5.6. This survey on the comparison of the text style of textbooks and the text style of student writing helped to inform this research of the need to encourage use of a variety of styles of writing in science depending on the context. For this reason contextual readings from a variety of sources were incorporated into the HCP modules.

Table 5.6
Comparison of Text Style and Student Writing Style

Text style	Textbook	Student writing
Conversational style	*In the previous chapter we saw that the effect on the impact of the people inside the colliding vehicles depended...* (De Jong et al. p. 309)	*By now we should be clear about the different types of current we normally use...* (student G3A1S)
Logical argument	*But suppose you make the tube on the right side weaker and use a piston...*(Hewitt p. 277)	*If you wish to convert AC to DC you will need the aid of a diode....*(student G3A1D)
Rhetorical	*One of the most exciting discoveries concerning science is that all of it is tied together by a few simple and fundamental mathematical relationships...*(Murphy et al. p. 3)	*As you can see there is physics everywhere. Physics can help save lives, by being applied in different ways. Also one little thing of the seat belt can have many explanations as shown here in the relation of the seat belt in the three laws of motion.* (student M3B1F)

Development of the SLDP

The information from the initial inquiries from questionnaires and reading resources, from the relevant literature and from the literacy experts, suggested that more varied reading materials and writing tasks were necessary and also it was desirable to improve students' commitment to writing and reading. The development of the computer-assisted HyperCard Pathways (HCP) model of scientific writing was seen as one way to do this. The intention was to present students with a novel approach to the task of extended writing in science and to integrate the four main activities: language acquisition, concept mapping, constructive dialogue, and extended writing within HCP modules. Also it was clear that teachers were wary of using valuable class time if the exercises were not directed towards explicit curriculum objectives. To this end, the SLDP components including the HCP modules, needed to be related directly to the physics topics being undertaken by the Year 11 teachers.

The Components of SLDP

The SLDP was constructed from a variety sources providing science knowledge, writing and reading skills, and a contextual focus for each topic that satisfied the required domains of the Physics Stage 1 Extended Subject Framework (SSABSA, 1991). The computer-assisted HCP model of scientific writing was prepared in four modules for four topics in Year 11 physics: electricity, magnetics, nuclear radiation and heat energy. The starting point for the development of the SLDP was determined by the availability of resources for the content knowledge, language acquisition techniques, and contextual readings for each topic.

The content knowledge was selected from the Year11 Example Program (Education Department of South Australia, 1988) and the Physics Stage 1 Extended Subject framework (SSABSA, 1991). Standard texts and supplements were used for the four selected topics. The modules were designed to fit the typical time allocation of three to four weeks for Year 11 topics.

The writing and reading activities for language acquisition were developed from a variety of language skills-based resources such as those of

Chaplen (1985), Bates and Dudley-Evans (1976), Bailey (1984) and Houston (1987) and writing exercises such as, paragraph writing, and sentence construction are contained in the lesson plan notebooks. A variety of styles and language registers was also included in the lesson plans. Team teaching between the researcher the participating teachers with the experimental groups was used. The SACE Writing Based Literacy Assessment criteria (SSABSA, 1992) were used for the assessment of the extended writing pieces. Exercises in the four macro literacy skills of listening, speaking, reading and writing were planned in classroom lessons and specific contextual readings are contained in the HCP modules. Permission for extracts was sought and obtained from the relevant publishers and references are cited in each topic module and also collectively in Appendix 7.7 of this thesis.

The contextual readings were selected from sources such as science magazines: Ecos , Discover, Australian Newspaper Computer and Science Supplement, Popular Science, and Genesis (References in Appendix 7.7). Extracts were selected and extensively edited to provide the contextual focus for each topic. The contextual readings were provided in the HCP modules to enable students to select concepts, new vocabulary and relational statements for use in concept mapping and the extended writing tasks.

Language Acquisition

The term language acquisition was used by Chomsky (1968) to describe the ability of the very young to acquire a first language. The claim was that human beings are born with a knowledge of a universal grammar and that this is used for rapid expansion of the use of language through what is termed the generative transformation. This theory claims that language users have the creative ability to produce and understand an indefinite number of syntactical arrangements of the language in the development towards more complex semantic components. Furthermore, Lemke (1990) claimed that cognitive development in terms of logical, mathematical and abstract reasoning powers is still increasing in adolescence while the ability to acquire native fluency in a language is decreasing rapidly at this time. Thus problems occur not only for ESL users but also for many students acquiring the language register of science. This maybe also the reason for the general perception of students that writing in science is least preferred, the most difficult, and the least enjoyable compared to other subjects. Therefore explicit teaching in language acquisition was seen as necessary in the SLDP. The three lessons of practical language acquisition are: elementary sentence construction, paragraph writing and the language register of science as described in the following paragraphs. A typical lesson pack of lesson plans is contained in Appendix 5.2.

Elementary sentence construction. To learn elementary sentence construction the students needs instruction and practice in recognising and using subject-verb-object (SVO) constructions, subject-verb-phrase (SVP) constructions and variations on these constructions. The use of punctuation, consistency in verb tense, personal pronoun, and singular/plural verbs and pronouns are contained in the lesson plans. This approach was adapted from texts such as Nucleus (Bates et al., 1981), Intermediate Scientific English (Chaplen, 1981) and The Role of English in Science Education (Kulkarni, 1988). Instruction in elementary sentence construction was seen as being particularly advantageous to students using ESL, of whom a higher proportion is often found in science subjects compared with English language-based subjects.

Paragraph writing. Paragraph writing in the SLDP consists of the analysis of four types of paragraphs that are commonly used in science writing. These types are:

* definition;
* description;
* comparison and contrast;
* sequence and consequence.

Explicit teaching of paragraphs of definition requires four parts to be presented in logical order: the concept or item name; the general class to which it belonged, whether it be a theory, abstract concept, general concept or observed application; features of the concept that distinguished it from others in the same class; and the uses or application of this concept or item. Students are given exercises for writing definitions relevant to the topic such as electromagnet (for magnetics topic), alpha particle (for nuclear radiation topic), hyperthermia (for heat energy topic), direct current (for electricity topic). Three or four sentences are required to form a definition paragraph.

Descriptive paragraphs require the use of adjectives and adverbs within elementary sentence construction. Lessons to provide examples and practice for students to write such paragraphs are planned in the SLDP and provided for teachers in the lesson pack (Appendix 5.2).

The use of comparison and contrast paragraphs is advocated through the use of the appropriate connectives. Similarly the development of sequence and consequence paragraphs is advocated with the use of illative connectives (explained later). The use of sentence and paragraphs connectives in this way conformed to the research findings of Gardner (1977, 1978, 1980) on the use of logical connectives in science.

The language register of science. The language register of science is seen to be a system of technical terms, codes, specialised vocabulary, equations and symbols. It has a characteristic syntax of causal, sequential and definitional phrases, clauses and sentences to express relationships between concepts. It employs diagrammatical, mathematical and specialised nomenclatures.

In the SLDP scientific relational statements were developed to include statements of composition, process, word analogue equations and mathematical equations. The use of a wide range of relational statements in concept mapping is designed to increase students' ability in this aspect of the science language register. Expressions of measurement including special units, instruments, quantitative and qualitative adjectives, proportional statements, and indicators of precision and accuracy are required in scientific writing. The ability of students to read and to use the conventions of measurement and to have a 'feel' for the orders of magnitude is seen to be conducive to scientific literacy.

Laws, hypotheses, rules and equations are found in the texts to be often couched in 'ideal' (meaning unreal) terms for example 'smooth', 'point source', 'test mass', and others. Knowledge of vector, mathematical and algebraic equations, and calculus expressions are seen as part of the language register of science and could be used in relational statements in concept mapping as well as for essay writing.

Graphs, tables and diagrams are regarded as common forms of scientific communication often used in scientific texts. The SLDP includes the use these expressions as part of the requirements for extended writing tasks. The ability of students to perform calculations based on arithmetical, algebraic or calculus algorithms is seen as necessary for scientific literacy, but these skills are not directly relevant to the extended writing tasks of

SLDP. Similarly, calculations normally required for reports of laboratory exercises are not specifically encountered in the extended writing tasks required here.

The specialised vocabulary for technological concepts arising from electronic technology, computer science and biological technology are seen as relevant to the SLDP. The contextual readings are provided for students to select these concepts and incorporate them into concept maps as one way of assimilating them into the mental cognitive structure.

Concept Mapping

The approach chosen for concept mapping here was that of the school of Science Education at Cornell University, New York (Novak & Gowin, 1984). Concept maps are intended to represent meaningful relationships between concepts in the form of propositions. Propositions are two or more concept labels linked by words in a semantic unit. Concept mapping can be described as a method of laying out ideas in a logically ordered map as a way of communicating abstract ideas and relationships in a visual manner.

The essential features of the Cornell type of concept maps are:

* hierarchical levels of concepts showing a general to specific progression;

* links and cross links showing the connections between concepts;

* branching of subordinate concepts that would form sub-groups or clusters within the general concept map;

* propositional statements about the relationships between concepts.

These four features formed the basis of the design specifications for the HCP modules discussed in the next section.

Three types of exercises in concept mapping are included in the SLDP. First there is the need to introduce students into the technique. This is done by using an analogy of mountaineering and applying it to hierarchical levels, pathways and concept names as shown in Figures 5.1 and 5.2, and are scored according to an amended scoring scheme of Cronin, Dekkers and Dunn (1982) as illustrated in Appendix 5.3.

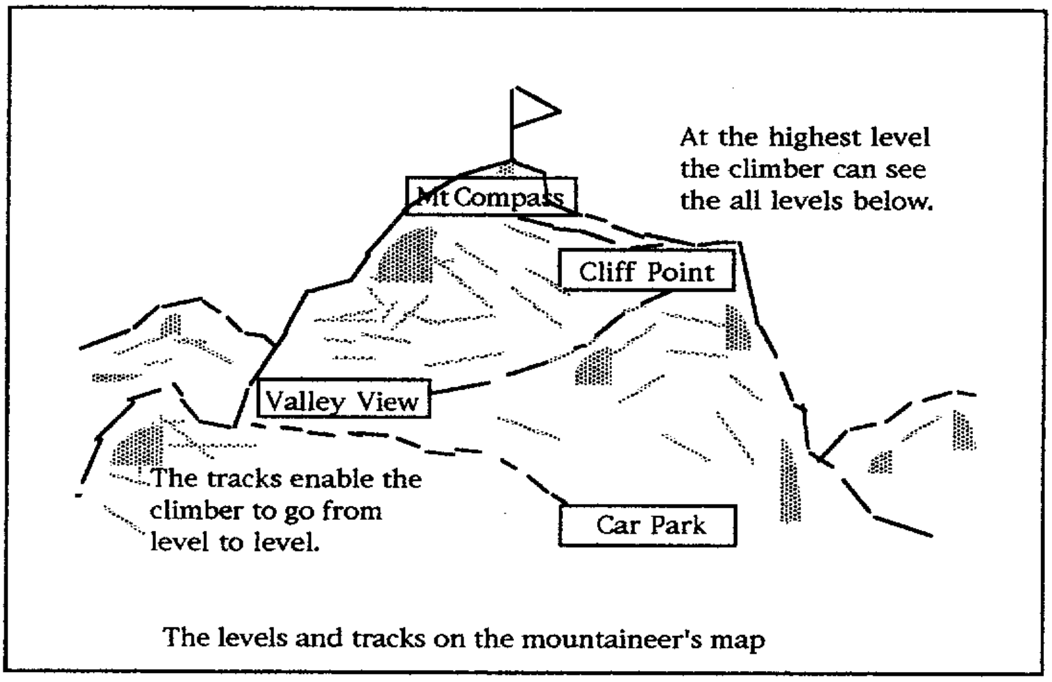

Figure 5.1. Analogy of mountaineering for concept map. (Pilot Study Lesson plan Notebook, 1991)

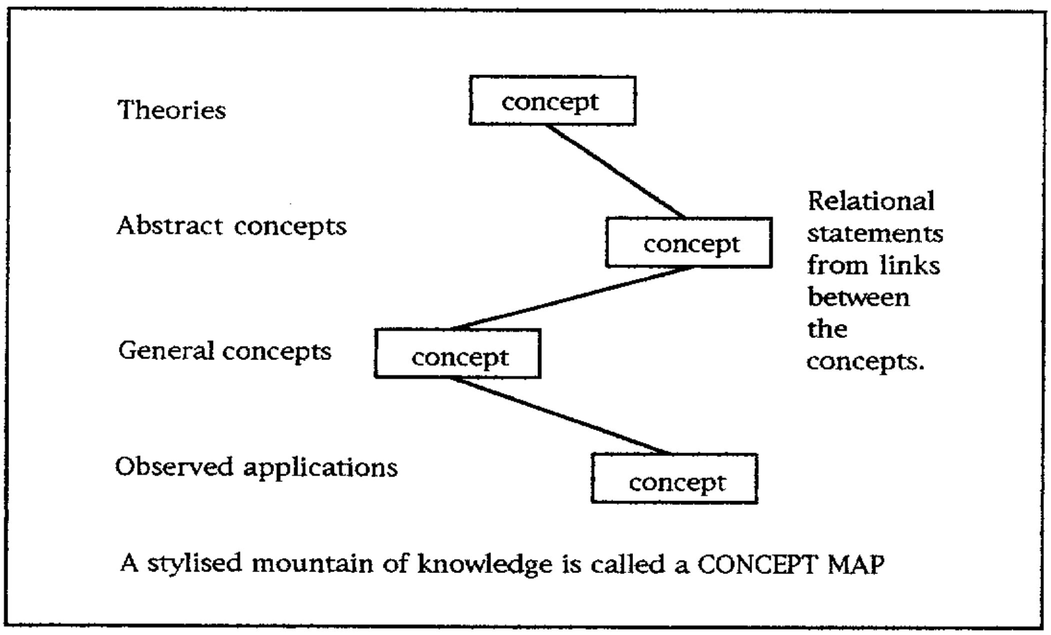

Figure 5.2. Hierarchical levels, links and concepts on the concept map. (Pilot Study Lesson plan Notebook, 1991)

The second task is to present simple exercises in concept map construction to students. For example, constructing a concept map of the theory of evolution is required given concepts such as food chain, living things, marine animals, tuna. A second exercise is the construction of a concept map of the Big Bang theory of the universe from concepts such as space, period of revolution, planets, light year. The construction is done by means of the HyperCard computing tools as explained later.

The second concept mapping exercise is to allow students to link the concepts within the relevant topics of electricity, magnetics, nuclear radiation, and heat energy. In this exercise, students are provided with eleven concepts in the form of concept words. The students are then required to build a general concept map using these concept words. A further facility to add new concepts and new relational statements is provided. This facility is made available through the HyperCard computing tools.

The third concept mapping exercise is the construction of a specific concept map for each specified essay. In this process, students are required to produce a concept map for a specific essay topic from a range of writing tasks within the general topic. It is assumed that development of the personal cognitive processes takes place as each student progresses with the personalised concept map and that this would form the scaffolding for the writing task. Assistance to students is provided through the contextual readings and through discussion with the teacher. These various facilities for concept mapping are made possible through the HyperCard computing tools.

Relational Statements

For simplicity, the term 'relational statements' is used synonymously with the Cornell term 'propositions' which is defined by Novak and Gowin (1984) as:

> Concept maps are intended to represent meaningful relationships between concepts in the form of propositions. Propositions are two or more concept labels linked by words in a semantic unit. In its simplest form, concept map would be just two concepts connected by a linking word to form a proposition. (p. 15)

In the SLDP, relational statements are to be introduced to the students as the connecting statements which were placed on the links between concepts. It was planned to introduce relational statements in three groups.

The first group consists of verb phrases such as: contains, is an example of, has, used in, belongs to, is measured by, is the property of, causes, has. These verb phrases were provided in the HyperCard computing menus.

The second group of relational statements are the logical connectives introduced to students with the mnemonic FANBOYS (Bailey, 1984) for connectives : for, and, nor, but, or, yet, so. These were called simple FANBOYS connectives because of their rating in the Logical Connectives in Science Project (Gardner, Schafe, Mynt, & Watterson, 1976). That research identified about 200 commonly used connectives in school science text material. Junior secondary students were tested by means of gap-filling and sentence-completion exercises to determine their facility in using the connectives. The connectives that were not used correctly in at least 70% of the gap-filling and sentences-completion exercises were labelled as difficult, and some were labelled as extremely difficult if there was a correct usage of less than 59%. In the explicit teaching of the SLDP, students are introduced to these more difficult FANBOYS connectives such as: furthermore, alternatively, noticing that, by way of, only if, yet to come, similarly. It is assumed that students would progress from the use of simple FANBOYS to the more difficult FANBOYS connectives.

As part of the second group of relational statements, illative connectives are introduced under SLDP. These connective were defined by Gardner (1978) as "terms which serve to introduce propositions which state an inference or a result" (p. 24). Gardner (1971) cites Carroll, Davies and Richman to show that illative connectives are a distinguishing feature of scientific writing. The SLDP therefore assists teachers to introduce terms such as: consequently, hence, so, thereby, therefore, thus. These were best introduced to the students in the lessons on paragraph writing (definition, description, sequence and consequence, comparison and contrast) described earlier.

The third group of relational statements are the technical phrases for each topic in physics, for example the particular laws and calculation rules that apply for electricity, magnetics, nuclear radiation or the heat topic as described below. The use of technical phrases by students allows them to link general concepts such as electrical energy to specific concepts such as current, potential difference and time (duration). Within the scoring scheme (Appendix 5.3) for concept maps (Cronin, Dekkers & Dunn, 1982) technical phrases are scored higher than connectives or verb phrases. This is to encourage the use of technical physics phrases in concept mapping as a preparation for using them in extended writing. The object is to prepare students to use physics laws in the linking of concepts both on concept maps and writing tasks as well as simply in calculations.

Contextual Readings

Richards et al., (1985) defined four types of reading for comprehension:

* literal comprehension;
* inferential comprehension;
* critical or evaluative comprehension;
* appreciative comprehension.

The first three are seen to apply to the SLDP for the following reasons: literal comprehension is needed to understand and use concepts and relational statements in concept maps and essays; inferential comprehension is needed to find and use information not explicitly stated in the passage and leads to some hypothesising in the writing of essays; critical and evaluative comprehension of reading texts is needed to compare information in a passage with the reader's own knowledge and values for this form of scientific writing.

The contextual readings were made possible through using the design features of HyperCard described later. Approximately ten contextual readings from a range of scientific magazines cited earlier are included in each HCP module. Of particular interest in South Australia is the use of the Genesis magazine from the Technology Development Corporation (South Australia) which features local scientific developments at Technology Park, Science Park and the proposed Multi-Function Polis.

The magazine texts are written in journalistic style and the challenge for students is to question opinions, identify unclear expressions, and examine the extent of scientific evidence presented. This questioning can be done with the teacher in constructive dialogue with students at computer work stations. The HyperCard computing tools make it possible to select and transfer concepts and relational statements from the contextual reading texts automatically to the concept map. This facility is thought to be an encouragement to students to develop the micro skills of reading:

inferential, evaluative, and appreciative comprehension over and above literal comprehension. The use of the transfer facility in HyperCard by students is an example of the 'pathways' model in action. The purpose of creating the HCP model of writing is to provide an explicit link between reading and writing.

Constructive Dialogue

It was anticipated that the arrangement of students working at computer terminals would provide the ideal situation for teachers and students to engage in constructive dialogue. It is in this situation that students operate in the Vygotskian "zone of proximal development" (Cole, John-Steiner, Scribner & Souberman [Eds. & Trans.], 1979) where spoken language precedes and facilitates the transition to written language. Constructive dialogue facilitates the transition to conventional written science such as replacement of sensory images with the symbolisation of images, the requirement for a different syntax in written language, and the non-interactive nature of written communication. This transition has been reported by Fleer (1990) where the scaffolding metaphor is used in the transition from informal to more formal language through one-to-one adult guidance because "learning is viewed, not as an individual construction of knowledge, but rather the joint construction of knowledge" (p. 116), as the student is directed through the zone of proximal development to a new level of potential development.

HyperCard Computing Tools

HyperCard is a product of *Apple* Computer Company for *Macintosh* machines. It has been used in many hypertext applications as described by McAleese and Green (1990) and is regarded as excellent hypertext facility. The advantages of HyperCard are seen by Boyle and Snell (1990) to be "extensibility, essential for adding intelligent navigation; availability, essential for testing and development; user interface, essential for acceptability." (p. 33). The disadvantages were seen to be the lack of " a graphical browser, into-links, stretch-text and multiple card displays" (p. 33), which were not required for SLDP.

The HyperCard software package was chosen for this research project, for the following reasons:

* the *Macintosh* environment is well known to be user-friendly;

* HyperCard is available to all users of *Macintosh* machines because it is supplied with every machine;

* the use of *Macintosh* machines is increasing in secondary schools.

HyperCard allows considerable choice in the creation of non-linear ways of linking of information. The links made by the individual users are called the navigation pathways. For ease of navigation, new *menus* were created and the standard *menus* of *file* and *edit* were modified.

Besides the hypertext navigation facilities, HyperCard also includes the text creation and graphics tools which are required for concept mapping. The integration of these facilities makes HyperCard a useful hypertext application for the development of modules in physics for scientific writing. The specific design features for the HCP modules are summarised in Table 5.7. The complete programming script of the HCP modules is contained in Appendix 5.4.

Table 5.7
The HyperCard Design Features

Requirements of SLDP	Modified design features of the HCP modules
User-friendly computing tools	* Provision of a modified *menus* and *menu bar* to assist students in the selection of the relevant tools for concept mapping, contextual readings and extended writing. * Provision of tools at *userlevel 4* to protect stacks from unwanted alterations but to allow students to *write-to* their individual discs. * Provision of numbered *cards* and *forward* and *back buttons* to allow ease of movement for students to construct their own pathways through the material. * Provision of a *lock* and *unlock* facility that would be accessible to teachers to make alterations as required for relational statements and contextual readings.

(continued over)

Concept mapping	* Provision of *buttons* for each concept such that they can be selected, located and re-located on the *screen* according the student's wishes. * Provision of *fields* containing relational statements that can be selected, located and re-located according to the student's wishes. * The provision of a *line tool* for students to link concepts that are related and an *erase tool* so that further alterations are made possible. * Provision of *new button* into which students can create new concepts and *new field* for relational statements that can be located on personal concept maps. * Provision of *erase button* and *erase field* tools for students to remove concepts and relational statements or *resize* them as they wish. * Provision of different *font styles* and *borders* to distinguish between concepts from relational statements on the concept map.
Contextual readings	* Provision of *cards* for short (225 words) extracts of contextual readings in *locked fields* but capable of being supplemented. * Provision of *bold style* to distinguish appropriate concepts in this topic for students to select if they wish. * Provision of *click chunking* tool for students to select *bold style* concepts for automatic transfer to their concept maps.

(continued over)

Extended writing examples	* Provision of a number of examples of extended writing that employ different language registers with *adjacent fields* for comments about the features of the example. * Provision of assessment criteria in *locked field* for students to become familiar with the requirements of extended writing.
Extended writing	* Provision of empty *unlocked fields* for students to construct their own extended writing from the construction of the personal concept map. * Provision of *buttons* for students to make rapid transfer to and from the concept map and return to the extended writing.

The HCP Modules

A list of topic concepts, concept definitions, relational statements, contextual readings, and concept mapping exercises were developed for each topic module. Each module was developed for a four week period according to the Year 11 Physics Example Course Program (Education Department of South Australia, 1988).The four modules are described below. A complete reference list for the contextual readings is contained in Appendix 7.7 as well as in the HCP modules with acknowledgment for permission to use these extracts.

Electricity

Concepts: conductor, insulator, volts, resistance, circuit, series, electrons, fuse wire, electromagnet, electric field, multimeter.

Relational statements: has, used, is a an example of, contains, belongs to, is measured by, is the property of, causes, for, and, nor, because, or, yet, so, by Coulomb's law, by Ohm's law, by electrical energy law, by electrical power law.

Contextual readings: Electric animals, from Physics One (De Jong et al., 1990); Electricity in medicine, from Medical Physics (Cameron &

Skofronick, 1978); Electron momentum spectroscopy, from Genesis, 6(3); An electronic invention, from Genesis, 7(3); Household electricity, from Physics One (De Jong et al., 1990). Starting the engine, from Physics One (De Jong et al., 1990). Solar aircraft, from Weekend Australian (23-2-85).

Magnetics

Concepts and applications: induced current, magnetics field, magnetism, electromagnet, repulsion, bar magnet, attraction, iron filings, magnetic north pole, magnetic south pole.

Relational statements: has, used, is a an example of, contains, belongs to, is measured by, is the property of, causes, for, and, nor, because, or, yet, so, by Ampere's law, by the magnetic field law, by the magnetic flux rule, by the induced emf rule.

Contextual readings: A no wheels railway, from Discover, 9(11); Magnetic resonance imaging, from Medical Physics (Cameron et al., 1978); Magnetic alloy against brain disease The Australian (11-2-92); Pulsars, from Ecos, 58; EMFs from power lines, from The Australian (18-2-92); A futuristic ship, from Weekend Australian (23, 24-2-1985); Unidentified flying objects, from The UFO Report 1990 (1992); Magnetic anomalies, from The UFO Report 1990 (1992); Magnetic processes in water purification, from Ecos, 21.

Nuclear Radiation

Concepts and applications: ionising radiation, non-ionising radiation, X-rays, micro Sv dose, Geiger counter, alpha radiation, radio isotope, gamma radiation, nuclear energy, half-life.

Relational statements: has, used, is a an example of, contains, belongs to, is measured by, is the property of, causes, for, and, nor, because, or, yet, so, by Einstein's nuclear energy law, by the half-life rule, by the photon energy rule, by the photoelectric law, by de Broglie's law.

Contextual readings: Ionising radiation, from Physics One (De Jong et al., 1990); Our natural radiation, from Physics One (De Jong et al., 1990); Thermonuclear fusion, from The Australian (11-2-92); Ultra-violet technology, from Genesis, 5(4); Medical cyclotron for PET, from The Australian (20-4-91); X-rays and CAT Scans, from Medical Physics (Cameron et al., 1978); Radioactive tracing, from Physics One (De Jong et al., 1990);

Carbon dating, from Physics One (De Jong et al., 1990); Chernobyl, from Radiation Exposures (Dalton, 1991).

Heat

Concepts: temperature, thermal emery, hypothermia, hyperthermia, insulation, Kelvin degree, evaporation, freezing, melting, thermometer, heat capacity.

Relational statements: has, used, is a an example of, contains, belongs to, is measured by, is the property of, causes, for, and, nor, because, or, yet, so, by heat capacity law, by the electrical energy law, by the calorimetry rule, by the law of heat flow in mixtures.

Contextual readings: Thermal nuclear reactors, from Physics One (De Jong et al, 1990); Greenhouse Effect, from Physics One (De Jong et al., 1990); Cryogenics, from Senior Physics (Moyle et al.1986); Infra-red medical radiation, from Medical Physics (Cameron et al.,1978); Body temperature, from Medical Physics (Cameron et al., 1978); Hyperthermia, from Physics One (De Jong et al., 1990); Hyperthermia, from Physics One (De Jong et al., 1990); Animal adaptations, from Physics One (De Jong et al., 1990); Atmospheric heating, from Physics One (De Jong et al., 1990).

Implementation Schedule of SLDP

The implementation of SLDP was planned around twelve lessons that were to be interspersed among the regular lessons in a four week teaching block at the convenience of the participating teachers. It was planned to teach half the SLDP in the normal classrooms and half at computer work stations to cater for those schools where access to the computer work stations for physics classes was limited. In schools where there was little difficulty with access to the computer work stations, it would be possible to teach all 12 lessons in the computer room. The teaching would also be enhanced wherever an overhead projection *data show LCD panel* was available. The participating teachers agreed with the implementation schedule of SLDP as depicted in Table 5.8. It was planned that both researcher and teacher would share the lessons in the pilot study according to the level of sharing desired by the teacher.

Table 5.8
Implementation Schedule of SLDP

Lessons in the classroom	Lessons in the computer room
L-1 Concept mapping	
L-2 Concept mapping	
	L-3 HCP Concept mapping
	L-4 HCP Concept mapping
L-5 Elementary Sentence Construction.	
L-6 Paragraph Writing	
	L-7 HCP Reading texts
	L-8 HCP Writing task
L-9 Language register of science	
	L-10 HCP typing
	L-11 HCP typing
L-12 Assessment review	

A number of individual double sided *double density discs of 720K* were prepared for students who were to take part in the pilot study

Interim Summary

A summary of the of the components of SLDP is illustrated in Figure 5.3 and the development from the presentation of just four SLDP activities in Chapter 1, Figure 1.1 can be seen. Further development took place after the pilot study. The components have been developed for specific lessons in the classroom and computer work stations. These lessons were organised according to the schedule for the trialling in the pilot study discussed in the next section.

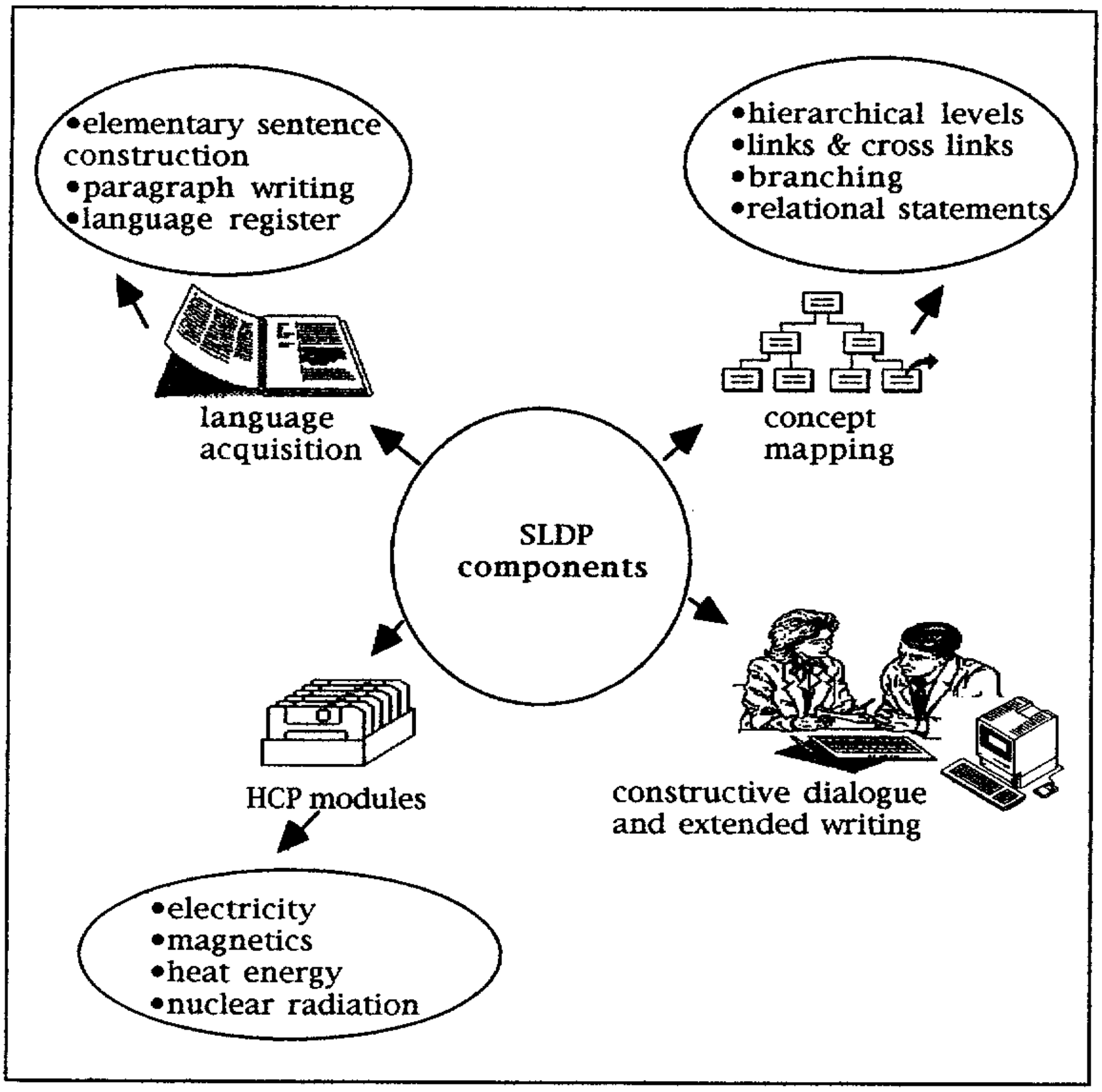

Figure 5.3. An illustration of the components of SLDP.

The Pilot Study

The pilot study was conducted in 1991 over a trial period of four weeks with experimental and control groups of Year 11 physics students. The objectives were: first, to explore the feasibility of using a standardised reading test for establishing a writing-in-science potential (WISP) scale for purposes of comparison between the experimental and control groups; second, to assess the effect of the SLDP on extended writing in a prescribed science topic in comparison with the control groups; third, to investigate any possible detrimental effect on student knowledge as a result of the time spent on SLDP; fourth, to conduct a post-SLDP student questionnaire and teacher questionnaire in order to develop and revise the SLDP for the extended studies.

Sample Selection

The selection of the experimental classes was determined by the availability of suitable equipment at trial schools, the willingness of the teacher and school authorities to be involved, and the researcher's desire to obtain a reasonably representative cross-section of Year 11 physics classes.

Equipment Requirements

Only schools with *Apple™ Macintosh* computer equipment could be considered for the experimental classes because the HyperCard software application was not transferable to other types of computers at the time of the research. In one case, class A-1, where the computer equipment was not available, the students were transported, with the appropriate authorisations, to a neighbouring school which had the required equipment. The experimental classes in the sample employed range of computer machines: *Mac Plus, Classic, LC and SE/30* machines. Other equipment requirements were either personal floppy discs for each student (supplied by the researcher) or a work station folder within the HyperCard application arranged by the network manager in each school.

Willingness of Trial Teachers

A second factor in the sample selection was the willingness of teachers, network managers, schools authorities and students to participate. This willingness was ascertained in a number of ways. First, the researcher met the teacher and discussed the teacher's willingness to allocate 12 forty minute lessons (or equivalent time) to the SLDP. In affirmative cases, the implementation of SLDP was then discussed to ascertain the most appropriate time for trial teachers and students.

Second, the researcher met the network manager and discussed the willingness to create work station folders for each student or create *start-up discs* to facilitate the use of individual floppy discs by the students. Some rescheduling of classes was done in some cases to accommodate the physics class in the computer room.

Third, the researcher gained the appropriate authorisation from all school principals as shown for one school in Appendix 5.5a, to allow the research to take place in the trial schools. As well, in the case of Education Department schools, the Agreement of Privacy (specifying anonymity of results, student acquiescence, and permission for publication of results) was sought and given as shown in Appendix 5.5b.

Fourth, the students' co-operation was sought. They were assured of the relevance of the SLDP to their physics course and the formative nature of any assessment given by the researcher. The commencement of the mandatory Writing Based Literacy Assessment (WBLA) in 1991 was a motivational factor for students and teachers to trial a scheme that would incorporate WBLA within the normal physics lessons.

Representativeness

In order to engage a wide range of factors affecting scientific literacy, a cross section of school types was selected for the trials of the SLDP. Initially the research project was advertised through the South Australian Science Teachers Association network and then a workshop was conducted by the researcher for interested teachers. A description of the range and types of schools that undertook the pilot study follows.

Sample Description

The pilot study was conducted with four experimental classes providing 92 students and two control classes providing 62 students for the sample indicated in Table 5.9. The alphabet characters represent schools and the numeric characters represent classes within the schools.

Table 5.9
The Pilot Study Groups

Experimental Group			Control Group		
School-class	Teacher*	Number of students	School-class	Teacher*	Number of students
A-1	Meg	16	B-1	Don	20
B-2	Fred	25	C-1	Beryl	21
B-3	Ned	23	C-2	Beryl	21
D-1	Myles	28			

* The teachers' names are pseudonyms.

The Experimental Classes

Class A-1. This was from an all-girls non-government school with a female teacher Meg, who had five years of teaching experience. The school was managed on a low fee structure, being assigned category 10 on the Commonwealth Resource Index (1992) in recognition of its low socio-economic clientele. Science equipment was adequate but minimal and no *Macintosh* computing facilities were available. Meg's normal teaching style was quite student-centred through much student-teacher interaction occurring frequently throughout a typical lesson. Meg was professionally active in attending science teachers' conferences and at the time of the pilot study was undertaking a graduate diploma course in physics education. Meg was enthusiastic about the trial even though it meant some disruption with transporting the students to another school for the computer lessons. The approximate composition of the class was two-thirds English speaking background and one-third Asian (Vietnamese) background. Only one or two of the students had any familiarity with *Macintosh* computers.

Classes B-2 and B-3. These classes were from an all-boys non-government school. The school was managed on a low fee structure being assigned category 10 on the Commonwealth Resource Index in recognition of its low socio-economic clientele. Science equipment was adequate and the school was well supplied with high quality *Macintosh* computing facilities. The approximate composition of the two classes was one-third English speaking background, one third Asian (Vietnamese) background born, and one third of other non-speaking background. Fred was a teacher with five years' experience and was professionally active in attending science teachers' conferences and at the time of the pilot study was undertaking a graduate diploma course in physics education. Fred was quite computer-competent and was actively engaged in the developmental stages of the HyperCard modules. Ned was primarily a mathematics teacher with two years experience with year 11 physics. At the time of the pilot study Ned was undertaking a graduate diploma course in physics education. Fred and Ned planned common teaching lessons. The two classes were quite familiar with *Macintosh* computers having had at least two years' use.

Class D-1. This class was from a co-educational non-government school with a medium fee paying structure. It was categorised at Level 7 on the Commonwealth Resource Index, because of its medium range socio-economic clientele. The science equipment was adequate but the computing facilities were very limited. There was one room with 16 machines to be shared by the whole school, primary and secondary. The machines also were of limited capacity with limited network capability. Myles was a highly regarded teacher of physics of some 12 years experience and was highly computer-competent. Myles also was a willing participant in the developmental aspects of the HyperCard modules.

The Control Classes

The classes in which the teachers agreed to be participants were B-1 and C-1 & 2. The involvement of these classes was for two lessons: one to complete a written assignment about the same physics topics as the experimental group and then a second written assignment four weeks later.

Class B-1. This class was from school B described above. The teacher Don was a very experienced teacher of physics and chemistry at both the secondary and tertiary level. Don was a willing participant but was not actively involved in the planning or review of the pilot study. The cultural and socio-economic background of the students were similar to that of Classes B-2 and B-3 described above.

Classes C-1 and C- 2. These classes were from a government high school in a low socio-economic area identified by parameters such as employment, income, dwelling of the social atlas of Adelaide (Bureau of Statistics, 1988). The teacher Beryl was a physics teacher of many years' experience actively engaged in the South Australian Science Teachers Association, in text book production and in curriculum development. Beryl's questions and comments about the pilot study assisted with its review. Beryl was also involved in the review of the results and contributed to the recommendations and refinements of the SLDP. Both classes consisted mainly of students with English speaking backgrounds.

Findings of the Pilot Study

Before an analysis of the trial results was undertaken, a pre-SLDP inferential reading comprehension test, TORCH (Mossenson et al., 1987) was given to students in all the experimental and control groups to ascertain their comparability in general reading/writing ability.

The Standardised Reading/Writing Test

A standard reading/writing test was selected with a scientific context, "The Red Ace of Spades" from the Tests of Reading Comprehension (TORCH) developed by Mossenson, Hill and Masters (1987). The tests aimed to assess the extent to which students were able to obtain meaning from a reading text and write answers in a cloze type exercise. A common scale provided a measure of reading ability that had been standardised for reliability and validity over Australia-wide norms.

The TORCH test results are expressed in normally distributed stanines of one half standard deviation in width. The test "The Red Ace of Spades" (Mossenson et al., 1987, p. 31) was selected because its reliability range extended from a lower Year 7 standard to an upper Year 10 standard and allowed some extrapolation to a Year 11 standard.

Results shown in Table 5.10, indicate there is no significant difference ($p > .10$) using a two-tailed t-test for difference of means between the reading/writing scores of the experimental and control groups. Although this result may seem good fortune, it is not surprising because similar schools were selected for the trials. From this result, it was concluded that the groups were comparable for the SLDP trial.

Table 5.10
Comparison of TORCH Scores between Experimental and Control Groups

Topic	Experi-mental group	$\bar{x}$ (SD)	Control group	$\bar{x}$ (SD)	Difference in means	Two-tailed t-value
Electricity	A-1 n = 16	5.62 (3.27)	B-1 n = 20	5.50 2.65	0.12	.98*
Magnetics	B-2 n = 25	5.75 (1.37)	C-1 n = 21	5.32 (2.52)	0.43	.66**
Magnetics	B-3 n = 23	5.37 (2.11)	C-2 n = 21	4.83 (2.75)	0.54	1.04*
Nuclear radiation	D-1 n = 28	6.11 (2.10)	NA	NA		

* $p > .10$
** $P > .20$

The Assessment of Writing Performance

The SLDP was used over a four week period to improve the writing performance of Year 11 physics students. Two extended writing tasks were given to the experimental and the control groups. The first was given at the commencement of the pilot study and the second was given at the end. The first and final writing tasks were similar. They were general enough to allow students to write at length even if their knowledge of the topic was inadequate, as would generally be the case for the first writing task. The second writing task contained a choice of either question A or question B as stated in Table 5.11.

Table 5.11

The pre-SLDP and post-SLDP Topics for Extended Writing

Topic	Pre-SLDP writing task	Post-SLDP writing task
Electricity	In what ways is electricity beneficial to humankind and in what ways is it harmful? How can it be made more useful and less harmful to human beings?	A. Write a letter to Michael Faraday (1831) to say how your life is affected by the uses of electricity. Explain to Michael the different forms of electricity and how they are generated. Describe how circuits and their various components are wired. B. Explain how AC and DC electricity are generated and how their various circuits make it possible for electricity to be used in many appliances. Explain some of the safety devices.
Magnetics	Explain from the point of view of a physics student how you encounter magnetism and electromagnetism in your everyday life.	A. Write a letter to Hans Christian Oersted to say how your life is affected by magnetism and electromagnetism. B. Explain the uses of magnetism and electromagnetism in the world today.

(continued over)

Nuclear radiation	You as a radio therapist have to tell your patient that he/she is to undergo radiotherapy. Explain as much as you can about the physics of the procedure.	A. You have a close relative, who understands some Physics and has to undergo a diagnostic scan for a tumour. This will be followed by RA Cobalt or Iodine treatment. Explain as fully as possible to him/her about the procedure from your physics knowledge. B. Explain the medical applications of radioactive isotopes.

The resulting essays were scored with an adapted version of the WBLA (Appendices 5.6a and 5.6b) for a maximum score of six. The six point scale included scientific criteria as well as the WBLA criteria. There were difficulties experienced with consistency of scores given by the participating teachers and the researcher. This required much discussion and eventual consensus but the process was time consuming and would not be suitable for the intended larger studies. This led to the development of a more formal method of essay assessment called the Scientific Explanation Genre Assessment scheme which is discussed in the next chapter.

Analysis of Results

A dependent one-tailed t-test indicated a significant improvement in mean scores ($p < .005$) for three of the four experimental classes as shown in Table 5.12. The improvement of the fourth group (D-1) was not statistically significant for reasons which may be related to the difficulties experienced while administering the SLDP to this group. The type of computers, and the type of network were inadequate for this size class. The machine manipulations were slow and the majority of students were unable to finish the task. The students also became frustrated with the machine delays. The comments of this group on the student questionnaire were markedly different from those of the other groups. These were valuable comments considered in the pilot study review and led to recommendations for the extended study described at the end of this chapter.

Table 5.12

Comparison of pre-SLDP and post-SLDP Writing Performance of Experimental Group

Topic	Experimental group	Pre-SLDP $\bar{x}$ (SD)	Post-SLDP $\bar{x}$ (SD)	Difference in means	One-tailed t-value
Electricity	A-1	5.80	8.80	3.00	2.76*
	n = 15	(3.10)	(2.86)		
Magnetics	B-2	4.67	7.86	3.19	3.50*
	n = 21	(2.80)	(3.10)		
Magnetics	B-3	5.05	7.86	2.81	5.32*
	n = 22	(1.46)	(1.96)		
Nuclear	D-1	5.63	6.63	1.00	1.14
radiation	n = 30	(3.13)	(3.55)		

*$p < .005$

In contrast to the experimental group, the control group showed only minimal improvement in writing performance, and this was not statistically significant ($p > .20$). The degree of improvement in writing performance of the control group is shown in Table 5.13. The difficulties experienced by the D-1 group (experimental) did not apply to the control group because the control group students were not required to use computer equipment. All other conditions of administration of the writing tasks were similar within general classroom conditions. Hence it is reasonable to assume that the SLDP influenced the improvement in the writing performance of the experimental group.

Table 5.13

Comparison of pre-SLDP and post-SLDP Writing Performance of Control Group

Topic	Control group	Pre-SLDP $\bar{x}$ (SD)	Post-SLDP $\bar{x}$ (SD)	Difference in means
Electricity	B-1	5.31	6.31	1.00*
	n = 16	(2.57)	(3.01)	
Magnetics	C-1	5.60	6.00	0.04*
	n = 16	(2.72)	(2.62)	
Magnetics	C-2	4.86	5.78	0.92 *
	n = 15	(1.83)	(2.22)	

* $p > .20$

There was a direct correspondence between success with the HCP modules and favourable comments in the post-SLDP questionnaire described later. The most success was enjoyed by classes B-2 and A-1, and the least by D-1. Some explanations for this are as follows:

Class A-1. Although this school had no *Macintosh* computers, the students were given the opportunity to visit a neighbouring school. Students were given the choice of doing this or doing the essay in the library. Twelve of sixteen chose the exercise with computers and produced concept maps with an average score of 43 using the Cronin et al. (1982) modified scoring scheme (Appendix 5.3), before commencing the extended writing task. Examples of one student's first extended writing (previous to the SLDP lessons), concept map and second extended writing are contained in Appendices 5.8a, 5.8b, 5.8c. The concept map was produced in a 50 minute lesson without any previous experience with *Macintosh* computers. An example of another student's paragraph writing is contained in Appendix 5.9. The four students doing the essay in the library did the extended writing task from pen and paper concept maps.

Class B-2. This school had a fully equipped laboratory of 32 computers linked with *digicard* and all students bought their own *discs*. The exercise was relatively smooth because the physics teacher, Fred, was competent with HyperCard and could give assistance to the students. This group had six lessons in the computer work stations and in addition many came along for a number of lunch times. The students were keen and 20 of the 21 students produced concept maps with average score of 65.

Class B-3. This group had the use of the same facilities as class B-2, but their time was more limited and the group experienced more difficulties in using the computing tools of the computer. Assistance was also limited for this group, as Ned was not as familiar with HyperCard as was Fred and hence not as many completed the final product. This group would have had approximately four lessons in the computer room plus their own lunch times. The number of students who completed concept maps was 11 out of 22 with an average score of 27.

Class D-1. This group had only limited facilities. There was one machine between two, and, in some cases, three students. The network was linked with *daisy chain* network which proved to be too slow for the multiple use of HyperCard computing tools. The room was heavily booked by the rest of the school and even though the physics teacher went to extraordinary lengths to swap lessons and even to take extra classes to get some available time, the students had only three lessons in the computing room. The students were able to read through most of the program, and a number progressed into the concept mapping exercise. Approximately three lessons were given to this exercise, but for many students it was a waste of time, hence their rather negative reaction to the post-SLDP questionnaire questions concerning the HCP modules of the SLDP. One student completed a concept map with a score of 35 using a stand-alone machine at a later date. Other students became interested when they saw this student working on a stand-alone machine, but further time was not available for each of them to complete the exercise individually.

Assessment of Content Knowledge

To ensure that the improvement in writing of the experimental group was not at the expense of knowledge about the topic, a test in physics knowledge on the topic was administered to each of the experimental and control groups. The topic knowledge tests in Electricity, Magnetics and Nuclear radiation were from Hewitt (1987), each for a maximum score of 16. The tests were standardised so that they can be used for comparative purposes and were selected from an item bank of over 1000 questions. Each test consisted of multiple choice items, true-false items and an extended writing question.

Table 5.14 shows that the means of scores of the experimental group were not significantly different from the means of scores of the control group ($p > .20$). The results show that the significant improvement in writing performance was gained without jeopardising knowledge and understanding of physics as measured by these tests. However, it is necessary to interpret these results within the limited objectives of this form of knowledge test. The tests relied more on lower order skills such as ability to recall, recognise, identify, and calculate. The requirement for analysis, synthesis and evaluation was not tested with the Hewitt knowledge test. Nevertheless, the test results provide an indication that time spent on administering the SLDP was not detrimental to the gaining of knowledge about the particular physics topic.

Table 5.14
Comparison of Experimental and Control Groups in Topic Knowledge Tests

Topic	Experimental group	Group $\bar{x}$ (SD)	Control group	Group $\bar{x}$ (SD)	Difference in means
Electricity	A-1 n = 17	11.06 (1.91)	B-1 n=21	10.95 (2.67)	0.11*
Magnetics	B-2 n = 23	11.00 (2.02)	C-1 n=15	11.13 (1.92)	0.13*
Magnetics	B-3 n = 22	11.32 (2.12)	C-2 n=16	11.75 (2.14)	0.43*
Nuclear radiation	D-1 n=24	10.17 (2.94)	NA	NA	

*$p > .20$

Observation of Problems Encountered

The students generally preferred working within the computer room than with the classroom lessons of SLDP. They were generally enthusiastic and creative in the tasks of concept mapping and writing although fluent typing presented problems for some students. The role of the researcher was to observe where problems occurred for students in manipulating the various computing *tools* within the HCP modules and to assist them as quickly as possible. A number of these problems arose and they were generally solved on the spot by the researcher and, in some cases, the participating teachers. However, some of the problems arose from serious deficiencies in the *script* of the HCP modules and caused setbacks for some students and inhibited them in completing all tasks. Examples of these problems are briefly described here.

There were non-repeatable concept *buttons.* This meant that once a concept *button* was used it could not be used again on the concept map. If the user tried to use the same *concept button* a second time, the original *button* would merely jump across to the new position leaving the old one vacant. The problem was in the creation of *new button* and the *script* had to be designed to recognise a repeated concept *button* as a *new button.* Initially this was overcome by telling students they could use each concept and each relational statement only once. This caused some creativeness on the part of students but also some confusion particularly for the weaker students.

There was limited movability of *concept buttons.* This meant that only the last concept *button* to be created could be moved around the *screen.* If the student wanted to go back and change the position of one of the previous *concept buttons* then the student would have to delete the concept and create it again. This caused considerable waste of time and frustration to the students.

There were unwanted *tool* options. When the student selected *line tool* or *erase tool* the *menu 'paint, patterns and options'* appeared. This meant that students could inadvertently select these *tools* and then not be able to get back out of them as the main *menu bar* was initially deleted. Again, waste of time and confusion were the result for some students.

There were *floating buttons* The *card buttons* 'go forward' and 'go back' that were used by the student to move through the module were not anchored on some of the *cards* in which *new button* was *scripted.* These *buttons* were floating and were accidentally erased when *clicked* to move to the next card. This meant that the student could not repeat a move to go back or to go forward. This was very frustrating to the student.

Different *fonts* caused some difficulties. Schools had different *fonts* installed in their systems and problems were caused when certain *field boxes* were not large enough to accommodate the typing required. In these cases the typed word(s) disappeared off the *field* and remained invisible.

These problems and others were to be addressed in the re-development and refinements to SLDP for the extended study.

Post-SLDP Student Responses

A post-SLDP questionnaire was given to 91 (out of a possible 92) students that took part in the experimental group of the pilot study although not all questions were answered by all students. Appendix 5.7a contains an example of the questionnaire and a typical response. Six questions about were asked writing in physics and results are summarised in the following paragraphs.

The response to the questions concerning the relevance of each component of SLDP to the extended writing task, was that students saw writing as necessary and helpful to the understanding of physics even though writing in physics was rated harder than writing in other subjects. This seems to be a more positive attitude than that revealed in the initial inquiry questionnaires. The exercises in paragraph writing and use of various forms of connectives in relational statements were perceived as helpful. Surprisingly, the computer-assisted concept mapping was not perceived as relevant as was pen and paper concept mapping or paragraph writing. A summary of these perceptions is shown in Table 5.15.

These results indicate that the connection between concept mapping and writing was not well understood. This led to a recommendation for revising the HCP modules giving back and forth pathways between the writing task and concept map, as well as pathways to reading texts. This would assist students to incorporate concepts from the contextual readings into concept maps and then into the extended writing.

Table 5.15

Students' Perceptions of the Value of Writing and Associated Techniques for the Understanding of Physics

Degree of assistance	Usefulness of Writing for the understanding of physics	Usefulness of pen and paper concept mapping	Usefulness of concept mapping with computer	Usefulness of paragraph writing with connectives
No help	6	20	27	12
Little help	3	5	16	6
Some help	34	30	20	35
More help	35	24	12	24
Much help	13	12	16	14

* n = 91

Students indicated favourable responses to the question concerning their desire to use the SLDP strategies again. Sixty eight students responded that they would use the strategies again if given the opportunity: 21 would use concept mapping again; 26 would use paragraph writing again; 21 would use all techniques again; and twenty three responded negatively, half of whom were from the D-1 group. This result provided encouragement for further development of the SLDP.

To the question concerning the writing styles required in scientific writing, the students perceived that there were two principal styles: laboratory reports and research assignments. This perception was different from that for other subjects as indicated in Table 5.16.

From this result it was concluded that students' understanding of the range of the genre required was determined largely by the type of writing task set by the teacher. It seemed that the explanation style of writing was not generally introduced until Year 12, where it became a necessity for the public examination. A recommendation was therefore made to include lessons in the revised SLDP, about language register, style and genre that would extend the range of students' style of writing in science. It was at this point that it was realised that a required part of the SLDP would be instruction about the genres of scientific writing. It was at this point that the term 'genre' was distinguished more clearly from 'style'.

Table 5.16
Students' Perceptions of the Writing Style for Various Subjects

Required style/genre	English	Humanities	Physics
Informal/narrative	68	10	8
Formal/report	5	24	32
Informal/explanation	19	19	21
Formal/research assignment	15	27	35

(n = 91 although not all responded for all subjects)

In response to the question in the questionnaire concerning the use of reading resources other than textbook, the majority of students indicated they did not read other than from the textbook. This is in indicated in Table 5.17. This result was only marginally better than the inquiry surveys (Table 5.3) and indicated that the revised SLDP needed to incorporate further strategies to facilitate the use of reading/viewing scientific resources.

Table 5.17
Students' Use of External Resources

Resource	Number of students with opinions				
	No use	Little use	Some use	More use	Much use
Books from school library:	37	10	37	2	2
Books from public library:	51	9	25	2	1
Science magazines:	56	8	20	4	3
Science in newspapers:	42	8	28	8	2
TV program "Beyond 2000":	12	11	31	14	20
TV program "Quantum":	55	8	18	1	9

(n = 91 although not all responded for all resources)

Post-SLDP Teacher Responses

The questionnaire was completed by the participating teachers and a summary of responses to a question about the general effectiveness is depicted in Table 5.18. A copy of the questionnaire and a typical response is contained on Appendix 5.7b.

Question 1

How do you rate the effectiveness of the SLDP strategies?

Table 5.18

Teachers' Perceptions of the General Effectiveness of SLDP Strategies

Strategies of SLDP	Number of teachers with opinions				
	No help	Little help	Some help	More help	Much help
Pencil and paper concept mapping	-	1	1	2	-
Computer-assisted concept mapping	1	-	-	3	-
Paragraph writing	-	-	1	3	-

(n = 4 teachers)

Due to the small number of respondents, it is possible to report the teachers' comments in full, as follows.

Question 2:

Was there too much time spent on this topic?

Comments:

Meg: *No.*

Fred: *I would like to see more time on computer-assisted concept mapping.*

Ned: *No.*

Myles: *Some students have not made the connection between concept mapping and writing.*

Question 3:

Do you think that you could use any of the techniques in you normal teaching?

Comments:

Meg: *I would really like to try using concept mapping as a means of clarifying concepts for the students and to help them with sentence construction and linking. The concept mapping exercise would be very useful in summarising a unit of work as well--whether it is done as a group activity, class activity or individually.*

Fred: *I would use both the drawing of concept maps and the computer-assisted concept maps. I would tend to spend initially a few lessons for introduction and then one lesson per week.*

Ned: *Paragraph writing, building up from definitions. Hopefully use the computer-assisted concept mapping next year.*

Myles: *Paragraph writing and essay writing skills sessions.*

Question 4:

What improvements can be made to:

(a) *drawing concept maps?*

Comments:

Meg: *More explanation*

Fred: *There probably needs to be more of an emphasis on individuality---no one concept map is correct. Otherwise it worked well.*

Ned: *Spend more time in class practising these.*

Myles: *Follow through concept maps with exemplar essays.*

Question 4 (b): *computer-assisted concept mapping?*

Comments:

Meg: *You can have two extra lessons for this. I enjoyed the experience. Some of the students did better than I did!*

Fred: *Apart from some of the problems faced with the program itself (which were rectified to a degree) the program was generally very well written.*

Ned: *More time.*

Myles: *I am not convinced that this is a better medium then pen/paper. Found the program difficult to use effectively.*

Question 4 (c) *paragraph writing?*

Comments:

Meg: *The students really improved their flow of writing. They appreciated the feedback on their paragraph writing.*

Fred: *More time needed to be spent with grasping concepts before beginning this.*

Ned: *More time.*

Myles: *This was well directed and understood by pupils; quite a useful exercise in essay writing method.*

Question 5:

If this was to be done in another school, what suggestions would you make?

Comments:

Meg: *I think there would be concern over the computers available at the school and how they are linked to a hard drive. It would be interesting to see the concepts taught all before concept mapping commenced. The use of concepts, theories etc need to be grasped before students attempt to formalise concept maps.*

Fred: *Build up the computer-assisted part with more practice in class in writing out concept maps. Initially just 3 or 4 levels before starting the more complex.*

Myles: *Forget HyperCard program and teaching concept mapping skills. Choose an earlier time of the year. Kids were distracted with press of exams near. Greater attention to core concepts (syllabus) and application. I suggest 2 sessions perhaps 3 times a year where teach: basic ideas of concept mapping; apply them; review and refine skills; evaluate effectiveness of concept mapping.*

Question 6:

Please comment on any other aspect of the four week trial?

Comments:

Meg: *Enjoyable and constructive experience. I used to miss out this topic but now I have found it very valuable and will include it from now on. It was well integrated into Prac work, concept development, calculations and tests.*

Fred: *The four week trial was cut down to three weeks only--which was nowhere near enough to really draw conclusions on the effectiveness of the program. The four week trial should have consisted of simply learning the writing of concept maps on a topic that had previously been studied. I was generally impressed with this approach to essay writing and will use this process in other science classes---Year 10 classes going into SACE would find this very helpful. Very impressed with the program itself---well written and fairly user friendly--would be nice to see a "colour" HyperCard as well as videos incorporated into the program.*

Ned: *Only had two and half effective weeks so I think the trial would have worked better over the four week period. Trying to cram the theory in was a little difficult and the students suffered information overload. I'm not sure how much of the theory sank in. The Hewitt tests direct the students towards the answers. They found them a bit too easy (some said they could see the answers on the multiple choice question sheet). Perhaps list several key words and get them to define/use them as a method of testing rather than the Hewitt tests.*

Myles: *Kids were frustrated by the perceived lack of content (I actually had a delegation of some 12 students see me about what their concerns were). I was a little concerned with the balance of my perceived value of concept mapping and paragraph writing against the coverage of topics. Too little attention was devoted to theoretical content and students reacted to this.*

Teachers opinions about SLDP can be summarised as follows: the drawing of concept maps were seen as valuable; computer-assisted concept maps were seen as more valuable; paragraph writing exercises were seen as most valuable. Other opinions were recorded in written comments which were used to make recommendations for a revised version of SLDP in preparation for the extended trials.

Analysis

An analysis of the SLDP pilot study was undertaken with independent assistance from the two thesis supervisors (named in Acknowledgments) in the following aspects: the achievements of the pilot study, the successful aspects of the SLDP to be incorporated into the extended study phase, the unsuccessful aspects, and the recommendations for improvements before an extended study was undertaken. A summary of these recommendations is depicted in Table 5.19.

This analysis indicates that the first research question was substantially answered, that is, the necessary components for an effective scientific literacy development plan were addressed by the seven components of SLDP trialled in the pilot study. The SLDP was judged to be effective in improving students' extended writing. Teachers saw that with some redevelopment and refinement SLDP could be effectively integrated into a Year 11 physics teaching schedule.

Limitations of the Pilot Study

The study was limited to a small sample of students from similar schools and with highly motivated teachers. The test for background literacy similarity between experimental and control groups was limited to a single standardised reading/writing test. A recommendation from the pilot study analysis was to extend the trials into a broader sample of schools and to broaden the measure of background similarity so that the effect of SLDP on similar sub-groups within the experimental and control groups could be compared. The development of a scale of writing in science potential was planned for the extended study.

The improvements shown by the experimental group in the pilot study were significantly greater than the improvements shown by the control group. However, some caution was needed in the interpretation of the quantitative results because of the difficulty with consistency in grading essays. Development of a more consistent assessment scheme was planned for the extended study phase.

The development of a scale of writing-in-science potential, the development of a consistent assessment scheme for extended writing and refinements made to the SLDP components would allow the second research question, namely, the general effectiveness of SLDP to be addressed.

The dialogue between researcher, teacher and students at the computer work stations was principally about computer operational skills. It was anticipated that improvements to the operation of the computer-assisted HCP modules would allow more constructive dialogue in regard to concept mapping and composition of essays.

Recommendations

Improvements for the implementation of the SLDP in the extended study are contained in Table 5.19 which represents a summary of the analysis and the recommendations for the extended study. The redevelopments and refinements to SLDP were prepared for the extended study in the following school year.

Table 5.19

Summary Recommendations from the Pilot Study

Components of SLDP	Recommendations for Improvements
Concept mapping	* Do this after the class teacher has taught a number of content lessons * Do concept mapping in groups * Use a variety of hierarchies
Computer-assisted-concept mapping	* Get rid of the *new button, script* and *new card* problems * Teacher familiarisation with HyperCard * Use concept maps related to the writing task. There needs to be a specific concept map for each writing task
Elementary sentence construction	* More time for small groups * Discuss the problem with English as a Second Language (ESL) and remedial teachers
Paragraph writing	* More practice with each of the four types of paragraph * More English Language Development Across the Curriculum (ELDAC) techniques
Language register	* Practise a number of examples * Remember the predominance of the explanation genre * Recommend more use in lower classes
Contextual readings	* Provide access to popular science magazines * Encourage discussion of 'Beyond 2000'
Writing tasks	* Refine the method of assessment * Give more advice to students about the marking scheme * Use word processor of HyperCard * Let students print their own concept maps and writing tasks

CHAPTER 6
THE FIRST EXTENDED STUDY

Introduction

Following the pilot study further development and refinements were made to the 1991 pilot SLDP for an extended trial in 1992. The production of a teacher's manual and the refinement and expansion of the HCP modules were undertaken. To assist answering the third research question about the general effectiveness of SLDP, expansion of the writing-in-science potential (WISP) scale and the development of a scientific explanation assessment scheme (SEGAS) were seen as necessary. These developments are described in this chapter, followed by a discussion about the extended study and its findings. The conclusions presented lead to recommendations for the second extended study.

Further Developments and Refinements of SLDP

The Teachers' Manual

For the extended study in 1992, it was planned to keep the intervention of the researcher to a minimum, so that the general effectiveness of the SLDP could be assessed when it was incorporated into the full semester work program of each teacher. Thus the participating teachers were to implement the entire SLDP without team-teaching with, or the requiring the presence of the researcher. To facilitate this change, a teacher's manual was prepared for the teachers of the experimental classes. The Teachers' Manual contained in Appendix 6.1 is a revised version of the one originally used in this first extended study.

The Teacher's Manual consists of an introduction to the purpose of the SLDP in terms of the objectives of the Extended Subject Framework for Physics (Senior Secondary Assessment Board of South Australia, 1991). These objectives are described in the Framework as follows:

Develop their (students') scientific literacy and in particular their use of physics terminology and notation;

Develop a variety of communication skills in situations which use physics;

Use their creativity and/or imagination to communicate about physics or physics related issues. (p. 12)

The Teachers' Manual gives the definition of scientific literacy and the components of the SLDP with an implementation schedule, similar to that of the pilot study. The difference in the first extended study was that participating teachers were not constrained to sequential lessons, nor to one particular topic. The Teacher's Manual contains a plan for the twelve lessons that address the components of SLDP, but it is not necessary for them to be done sequentially. This enabled teachers to implement the components of SLDP according to their own course schedules.

To complement the Teacher's Manual, specific lesson packs were assembled for each topic of the extended study. These lesson packs are similar to that in Appendix 5.2, which consists of a number of overhead transparencies for each of the SLDP lessons outlined in the Manual.

The Expansion of HCP Modules

The HCP modules were expanded to four new modules described below, and the existing modules, electricity, magnetics, heat energy and nuclear radiation, from the pilot study were further refined.

Refinements to Existing Modules

Refinements that took place in the HCP modules were in response to the problems observed in the pilot study which were associated with: *new button, new card*, non-repeatable concept *buttons*, limited mobility of concept *buttons*, unwanted *tool options*, floating *buttons*, different *font*, printing problems and network problems. The problems were rectified at the *scripting* level of HyperCard and this can be found in the *script* as illustrated for one topic in Appendix 5.4.

The pilot study HCP modules namely, electricity, magnetics, nuclear radiation and heat energy, were refined and made more accessible to students through copies of *floppy discs* or by storage on *hard disc* systems. Within each module, further navigation pathways through concept mapping, units of contextual readings, units of writing models, and the essay typing fields were provided. The choice of pathway was presented to the user more clearly, as illustrated in Figure 6.1.

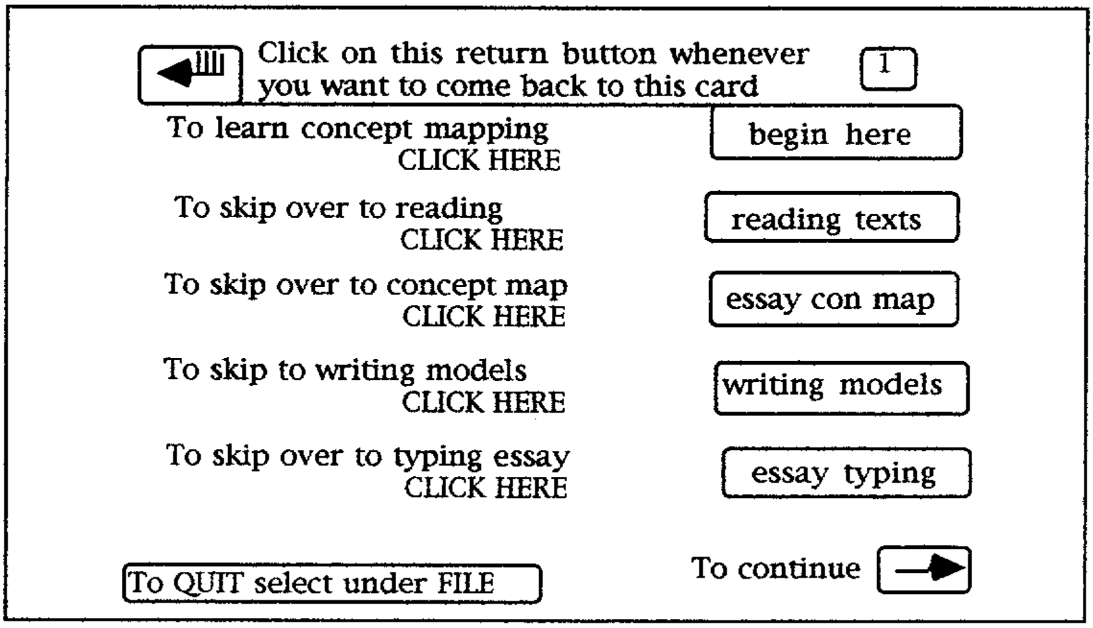

Figure 6.1. Pathways to program units.

The New HCP Modules

The same general format of the HCP modules developed in the pilot study was preserved and the number of topics in physics was expanded to eight, as illustrated in Figure 6.2. The new topics were: light, dynamics, electromagnetic radiation, and sound. Each module was approximately 300 K in size and students were able to store each module on personal *floppy discs*. The whole program also was designed to be stored on *hard disc* and accessed at any of the modules through HyperCard *buttons* as in Figure 6.2.

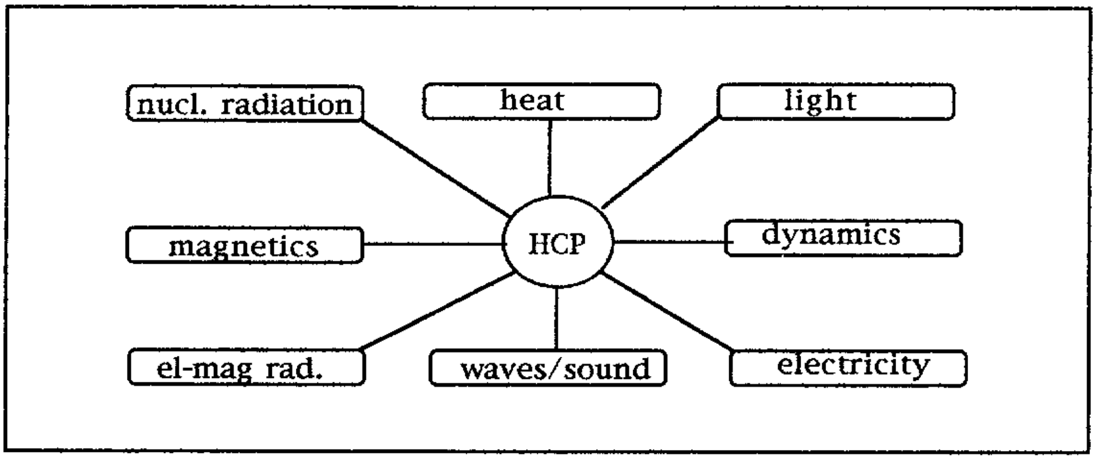

Figure 6.2. HyperCard Pathways modules.

The New HCP Modules

A list of topic concepts, concept definitions, relational statements, contextual readings, and concept mapping exercises were developed for each topic module. Each module was developed for a four week period according to the Year 11 Physics Example Course Program (Education department of South Australia, 1988). The four modules are described below. A complete reference list for the contextual readings is contained in Appendix 7.7 as well as in the HCP modules with acknowledgment for permission to use these extracts.

Light

Concepts: wavelength, reflection, colour, spectrum, wave theory, refraction, total internal reflection, lens, optometrist, frequency, focus.

Relational statements: has, used, is a an example of, contains, belongs to, is measured by, is the property of, causes, for, and, nor, because, or, yet, so, by angle i = angle r, using refractive index, using lateral inversion, describing the projected image.

Contextual readings: Laser eye corrections, from The Australian (19-10-87); "Endeavour" explores the mysteries of space, from The Australian (21-1-92); Seeing the light beyond the spectrum, from The Australian (4-2-92); Motion control, from Genesis, 7(5); Ophthalmic lenses, from Genesis, 7(2); Robot vision camera, from Genesis, 6(5); A talking computer for the visually impaired, from Genesis, 5(6); Desert mirage, from The Physics Teacher, 29(1).

Electromagnetic Radiation

Concepts and applications: electromagnetic waves, frequency bands, radio waves, microwave, visible light, wavelength, skin cancer, telecom, electromagnetic radiation theory, sunburn.

Relational statements: has, used, is a an example of, contains, belongs to, is measured by, is the property of, causes, for, and, nor, because, or, yet, so, by c = speed of light, f = frequency, λ = wavelength, using $c = f \times \lambda$.

Contextual readings: Sun protection factor, from Medical Physics (Cameron et al., 1978); Electromagnetic radiation, from Physics One (De Jong et al., 1990); Brain scans, from Ecos, 74; Sun on the skin, from Ecos, 48; Ultra violet technology, from Genesis, 5(4); Radio waves, from Dictionary of Science (Schneider & Schneider, 1988); X-rays and CAT scans, from Medical Physics (Cameron et al., 1978); IR photography in medicine, from Medical Physics (Cameron, 1978). RADAR, from Genesis, 6(5).

Dynamics

Concepts and applications: mass, velocity, momentum, potential energy, kinetic energy, conservation of momentum, collisions, elasticity, dynamics theory, Newton's cradle.

Relational statements: has, used, is a an example of, contains, belongs to, is measured by, is the property of, causes, for, and, nor, because, or, yet, so, in an isolated system, $\delta p = mv - mu$, with vector sign change, adding vectors.

Contextual readings: Transfer of momentum in sports, from Physics One (De Jong et al.). The joy of moving, from Moving With Physics (Beruldson, 1991); Effects on the body, from Medical Physics (Cameron et al., 1978). Parachuting, from Medical Physics (Cameron et al., 1978); That's dancing, from That's Dancing (Dow, 1985); Working with the body, from Physics One (De Jong et al., 1990); Triathlons, from Triathlon Training (Scott, 1986); Car inventions, from Physics One (De Jong et al., 1990); A future planet, from New Earths (Oberg, 1981).

Sound

Concepts: reflection, resonance, decibel, wavelength, refraction, longitudinal, ultrasound, Doppler effect, music, frequency, amplitude.

Relational statements: has, used, is a an example of, contains, belongs to, is measured by, is the property of, causes, for, and, nor, because, or, yet, so, by $v = f \times \lambda$, by $v = d / t$, using beats, changing pitch.

Contextual readings: The bionic ear, from Weekend Australian (5-6-87); Silencing industrial noise, from The Australian (31-3-92); Decibels, from Dictionary of science (Schneider & Schneider, 1988); Stethoscope, from Medical Physics (Cameron et al., 1987); Electronic music, from The Australian (10-8-88); Sonar, from Genesis, 7(3); The noise that offends, from Ecos, 17; Human speech, from Medical Physics (Cameron et al., 1978); Ultrasonics, from Medical Physics (Cameron, 1978).

Writing in Science Potential (WISP) Scale

In the 1991 pilot study a single test for literacy, namely the TORCH (Mossenson et al., 1987), was used to establish a benchmark across all experimental and control groups in order to ensure that the comparisons being made were between groups with approximately the same average reading/writing ability. In this extended study, a more comprehensive measure was developed in order to compare sub-groups of students from both experimental and control groups who had approximately the same potential for reading/writing in science. This more comprehensive measure was called here the 'Writing-in-Science Potential' (WISP) and allowed student results to be divided into three sub-groups: high WISP, middle WISP and low WISP. It was defined as a combination of TORCH results, the Writing Based Literacy Assessment (WBLA) and the semester physics results from the school, which were collated independently of each other. This combination of results encompasses reading, writing, and physics knowledge. The students themselves had no knowledge of the WISP categories, which were for research purposes only.

The WISP Scale

High WISP. Students to be categorised in this sub-group would be those in which a combination of the following three independent measures was found: TORCH result in the highest two stanines: 8, or 9; WBLA result needed to be satisfactory at the first attempt; and the semester physics result needed to be A (or a mark of 17+ to 20) or a high B(or a mark of 16 to 17). (Teachers in South Australia have the option of giving grades A to D or assigning a mark out of 20).

Middle WISP. Students to be categorised in this sub-group would be those in which a combination of the following three independent measures was found: TORCH result in the stanines: 5, 6 or 7; WBLA result needed to be satisfactory in at least the second attempt; and the semester physics result needed to be B (or a mark of 14 to 15) or C(or a mark of 12 to 13).

Low WISP. Students to be categorised in this sub-group would be those in which a combination of three independent measures was found: TORCH result in stanines less than 5; WBLA result given as Requirements Not Met; and the semester physics result a D (or a mark less than 12).

To be categorised into a sub-group the highest level in all three criteria needed to be met. The purpose of dividing the groups into high, middle and low WISP was to investigate whether the effectiveness of SLDP varied between the different sub-groups. Later a 'special WISP' group was created as a result of the findings of the extended study, in order to categorise the results of students who showed low ability with language and high physics achievement, such as students from a non-English speaking background for whom the above categories would not be suitable. This led to an expansion of the three point scale to seven bands of WISP in the second extended study described in the next chapter.

Development of the Scientific Explanation Genre Assessment Scheme (SEGAS)

The need for developing a Scientific Explanation Genre Assessment Scheme (SEGAS) arose from the difficulties experienced in the pilot study in trying to get consistency in marks awarded between the researcher and the participating teachers. The assessment procedure in the pilot study attempted to rate students' extended writing according to scientific criteria, as well as the criteria for WBLA, and to assign scores from 1 to 6 beyond that of being merely satisfactory for WBLA. Due to the difficulty of finding some consistent and time efficient method of scoring beyond WBLA, a formal assessment scheme was developed, for use in this extended study.

A number of schemes in the literature focus on language features as indicators of writing competence, such as those of Stewart (1992), Macken (1989), Daly (1990), and Cox and Haynes (1991). However, the requirement here was for a scheme that graded the quality of scientific writing in the explanation genre according to both scientific features and language features. A supporting statement is that of Martin (1990):

> Writing in science is different from writing in other parts of the curriculum and scientifically oriented criteria have to be used to evaluate it. Developing subject-specific criteria for evaluating writing is an urgent need in Australian schools. (p. 81)

To establish such criteria it was first necessary to recognise the genre of scientific writing being used. From the literature it seemed that there were various scientific genres. They were laboratory reports, recounts of field experiences, explanations of concepts within a network of related concepts, exposition in support of a certain scientific position, and the discursive argument within a range of scientific positions. Development of an assessment scheme for the scientific explanation genre was seen as most relevant for the extended study for reasons discussed below.

The Scientific Explanation Genre

According to Richards et al. (1985), the genre is a class of discourse events which are considered by a particular discourse community to show particular and distinctive characteristics. Genre is described by Callaghan (1989) as having a distinctive schematic structure, a distinctive beginning, middle and end. O'Sullivan et al. (1983) say that:

> You can't isolate what kind of characteristics indicate distinctions between genres; it's not just subject matter, nor just style, nor is it the establishment of distinct conventions appropriate to each genre. It is all of these and becomes clear when compared with other genres (p. 99).

The purpose of the explanation genre, according to Hardy and Klarwein (1990), is to explain why things are, how they are formed or made, and the stages of that process. Martin (1990) refers to the characteristics of scientific explanation genres as having a high percentage of action verbs for actions which are organised in a logical order. They feature generic as well as specific terms and make use of timeless verbs.

According to Martin (1990), the explanation genre is the main source of extended writing required of science students. This is supported by the Whitehouse and Sullivan (1992) research into the Year 12 science public examinations in South Australia. In 1989, the physics essay question (16% of total marks) was changed to conform more closely to an explanation genre. For example, the intent of the questions was indicated by instruction words such as 'explain', 'give a reason', 'why', 'give an explanation for' and other similar phrases. The essay questions were designed to make demands on the students' reasoning skills and to show an understanding of scientific relationships (Whitehouse and Sullivan (1992, p. 32). This change had the effect of reducing gender difference which had previously been evident, but it did not reduce the difference between the performance in essay writing and overall performance. In contrast to biology, the physics examiners from 1989 to 1991 rewarded the logical discussion of ideas which utilised appropriate selections of content to support an argument rather than a reiteration of learned facts. An essay format was required rather than note form, or summaries of data.

To make this research as relevant as possible to the future needs of Year 11 students, the focus was narrowed to the scientific explanation genre in the extended study. This required some assistance for teachers as science teachers, on the whole, are untrained in genre-based strategies of writing and the exploration of multiple genres of writing in science.

In the face of this inadequacy, it became the task of this research to develop a scheme that correlated with the definition of scientific literacy and was specific to the writing tasks of Year 11 Physics students. The Biggs and Collis theory (Biggs & Collis, 1982) about levels of structure of observed learning outcomes provided a taxonomy that could be adapted to this task. It was to form the link between the WBLA criteria and the criteria for physics assessment as shown in a prototype version of SEGAS in Appendix 6.2. The taxonomy is called the Structure of Observed Learning Outcomes (SOLO) and is based on a cognitive theory of development. The SOLO taxonomy has been used in research studies into student progress in science achievement (Biggs & Collis, 1989) as well as in a number of classroom applications for at least three purposes: test design (Collis & Davey, 1986), curriculum design (Stanbridge, 1990), and student assessment (Pallett & Rataj, 1991).

Biggs and Collis avoided the structuralist view of development stages in the traditional Piagetian sense of pre-determined stage development. They also avoided the notion of task-related stages in which the cognitive stage was seen as an artefact of task performance, being solely determined by task familiarity. Instead, Biggs and Collis (1982) adopted an interactionist view of cognitive development, which sees the stage phenomena as the result of continuous interactions between the evolving cognitive stage and the particular task requirements. At the Year 11-12 level Biggs and Collis (1989) found that a transition was taking place from concrete-symbolic mode to an early formal mode of relational and extended abstract responses. They found that students were beginning "to question how things are, and instead of accepting them, form hypotheses about how they might be" (Biggs & Collis, 1989, p. 156).

Adoption of this interactionist view of modes of response meant that Biggs and Collis described levels of qualitative attainment according to the structure of student responses rather than solely according to the developmental cognitive stages of the students. The SOLO taxonomy was valuable for this research in that it provided a method to assess the scientific explanation genre for three observed learning outcomes: first, evidence of a minimum standard referred to as foundational criterion and corresponding to the WBLA requirements; second, language indicators at more advanced levels to assign grades of performance beyond WBLA; third, evidence of structured and logical development of scientific concepts as an integral part of writing performance.

Biggs and Collis (1989) analysed student responses according to the structure of observed learning outcomes and classified them as prestuctural, unistructural, multistructural, relational and extended abstract responses as follows.

Pre-structural responses. These responses are indications that the writer does not understand the task or is distracted or misled by irrelevant aspects and cannot form statements related to the topic in any coherent way. These responses therefore would not meet the requirements for a satisfactory WBLA, and therefore of SLDP assessment.

Unistructural responses. These responses indicate that the writer focuses on one relevant aspect and writes in short unconnected statements rather than in prose demonstrating coherence and fluency as required for a satisfactory WBLA.

Multistructural responses. These responses indicate that the writer picks several relevant or correct features, but does not integrate them. This is detected in student essays in which the language features of paragraph writing are lacking for example a paragraph theme such as definition, description, comparison and contrast, consequence and sequence as described earlier. These responses may be minimally fluent and coherent and would be graded satisfactory for WBLA.

Relational responses . These responses indicate that the writer knows how to integrate the parts of an explanation or argument with each other so that the whole has a coherent structure and meaning. Advanced use of language indicators and scientific relations are found in these higher level essays and there are clear indications that the explanation was understood.

Extended abstract responses. These responses indicate that the writer can generalise within the structure of the writing task and take in new and more abstract features, representing a higher mode of operation. This level of response indicates assimilation of concepts into personal cognitive structures, as proposed in the definition of scientific literacy.

The above descriptions formed the basis for the development of the Scientific Explanation Genre Assessment Scheme (SEGAS) which is described in the next few paragraphs.

The SEGAS Criteria

This scheme was adapted from the SOLO taxonomy for assessing scientific writing beyond satisfactory achievement of the foundational criteria of WBLA. A grading scheme with three categories (A, B, and C) of observed learning outcomes in linguistic features was adopted with two further sub-categories of (+) and (-) in each of the three categories for the observed learning outcomes in scientific features. This provided a method to assess the structure and logical sequence of the overall explanation writing task. The criteria are described as follows.

Multistructural criteria. Essays that meet the foundational criteria of WBLA would be graded at least a 'C' in which the purpose of each paragraph was clear enough with several related concepts being appropriately grouped in each paragraph. Sentences would be adequate but not generally linked either linguistically or structurally. These essays would use scientific concepts but would have little development of them.

If sufficient relevant scientific concepts were introduced then it would satisfy the criterion for a range of concepts being used, and a sub-category of (+) is awarded. Also essays which indicated a range of applications of the scientific concepts would be considered for a 'C+'. The presence of incorrect scientific concepts would cause essays to be down graded to a 'C-' sub-category.

Relational criteria within paragraphs. In this category there would be logical connection between sentences within each paragraph. One indication would be an extensive use of appropriate language connectives between the sentences. Other connections may be made by lexical and cohesive devices. The grammatical devices of cohesiveness would be structural connectives, modifying connectives, as well as expressed scientific relationships. An essay which exhibited these kinds of language indicators would be analysed for a 'B' category.

Specific scientific relations such as scientific equations, word analogues of equations or mathematical expressions used to develop and extend concepts would indicate a sub-category of 'B+' while incorrect scientific relations would cause essays to be down graded to a 'B-' sub-category.

Relational criteria throughout the essay. In this category there would be logical development between paragraphs towards forming a solution or conclusion. The paragraphs would follow some order such as general to specific, or from definition to application. Consequential or sequential development from paragraph to paragraph would be further evidence of logical development between paragraphs, thus meeting relational criteria throughout the essay. Essays with these kinds of indicators would be graded an 'A' category.

If the essay also shows scientific linking of theories and principles with equations laws and mathematical expressions, it would be relational in its scientific structure as well. Such essays would be graded an 'A+' sub-category while an essay which contained a misleading or incorrect application of theory would be given the 'A-' sub-category.

Extended abstract reasoning. In this category essays would exhibit a conclusion or solution left open for further hypothesis and would be an indication of extended abstract reasoning. Because of the nature of the explanation genre, extended abstract features often may not be observed, but such features become quite significant in the discursive argument genre of writing, and lie beyond the focus of this assessment scheme. Evidence of hypothesising, theorising and the introduction of relevant metaphors and analogues in explanation writing would be awarded the 'A+' grade.

Summary of SEGAS. A summary of the SEGAS criteria is presented in Table 6.1 and Appendix 6.2b. The scheme allows a scorer to proceed logically through the criteria. To achieve reliability in assessment, the scorer would progressively assess each level of criteria in the scheme and decide at what point the assessment changes from being 'adequately met' to 'not adequately met'. The highest level at which the criterion is judged 'adequately met' determines the grade. Inevitably there will be some essays which have sections that meet some criteria and sections that do not. A professional judgement about the balance of these sections would need to be made. This is the point at which some inconsistencies between the studying markers occurred for a small number of essays during the trialling of the scheme.

Table 6.1
<u>The Scientific Explanation Genre Assessment Scheme</u>

SEGAS	Criteria	Assessment: (Adequate to Not adequate)	Grade
Foundational criteria:			
	* legibility, layout and length		
	* spelling, punctuation, grammar		
	* sentence and paragraph construction		
	* consistent language register		
	* fluent and coherent for the reader	'------'	C
Multistructural criteria:			
	* range of relevant scientific concepts and/or applications to everyday life	'------'	C+
	* NEGATIVE: incorrect scientific concepts	'------'	C-
Relational criteria within paragraphs:			
	* logical development and use of language connectives between sentences	'------'	B
	* specific scientific relations such as equations, word analogues that show development and extension of concepts within the paragraph	'------'	B+
	* NEGATIVE: incorrect scientific relations	'------'	B-
Relational criteria throughout the essay:			
	* logical development between paragraphs and progression towards a solution or conclusion	'------'	A
	* linking of scientific concepts, principles and theories, with equations, laws and mathematical expressions that link all sections of the essay	'------'	A+
	* NEGATIVE: misleading or scientifically incorrect applications of theory	'------'	A-
Extended abstract reasoning:			
	* hypothesising, theorising and formation of open conclusion for the discursive genre	'------'	A+

Trialling the Assessment Scheme

The assessment scheme was refined during a series of trials using representative samples of explanation essays of Year 11 physics students written in response to a wide variety of essay titles by a group of three with relevant expertise, consisting of a university physics lecturer with extensive experience in marking Year 12 public examinations, a former English consultant, who was one of the initiators of WBLA with extensive experience in marking Year 12 English, and the researcher with extensive teaching experience. The procedure was first to grade a sample of essays independently, awarding grades from C- to A+ for those above the WBLA foundational standard. For the purposes of comparison, the grades were then converted to scores of 1 to 9 which enabled means, standard deviations and inter-scorer correlations to be calculated. Then, collaborative marking was done in order to make refinements to the assessment scheme. A second sample was then independently graded resulting in a closer inter-scorer correlation. After further collaborative marking and refinements to the scheme, a third larger sample was independently marked yielding a mean inter-scorer correlation (r) of .66 and an effective reliability of correlation (R) of .85 as seen in Table 6.2. The Effective Reliability (R) allows for the number of scorers as well as the mean of inter-scorer correlations after the method of Rosnow and Rosenthal (1993). The final step was to invite a group of four practising Year 11 physics teachers to study the scheme. The mean inter-scorer correlation for this group was $r = .53$ ($df = 10$, $.05 < p < .10$), and the effective reliability was .82. These results were regarded as educationally significant, in comparison to results from other forms of essay marking. The results of the trials are shown in the Table 6.2.

Table 6.2
Results of Successive Trials of the SEGAS

Trial	Number of essays	SD between means	Mean of inter-scorer corr. (r)	Effective reliability of corr. (R)
first	7	1.20	.50	.75
second	6	0.61	.89	.96
third	15	0.82	.66	.85
fourth	12	0.51	.53	.82

The SEGAS was the main instrument to be used in grading student extended writing by the researcher in consultation with the participating teachers in both the experimental and control groups. After conversion of grades to a numeric scale of 1 to 9, the scores could be used to give quantitative measures of group means and standard deviations. The group statistics could be used to form comparisons between the experimental and control groups to establish the general effectiveness of SLDP. It was also anticipated that the SEGAS could also be used independently by teachers.

Duologue

The term 'duologue' was now used instead of constructive dialogue to emphasise the value placed on this form of dialogue by Lemke (1990). Duologue is defined in the Oxford dictionary as the specific dialogue between two people. It allows for more colloquial and more humanised ways of talking science which are called "norm-violations" by Lemke (1990, p. 136). The student feels comfortable talking in this non-stylised way one-to-one with a teacher or neighbour. Here the student's opinion or real life experience can be relevant to the task. The interaction in the duologue can assist in undermining the detrimental mystique of science with the following possibilities:

* describing the actual relation between observation and theory;
* describing science as a fallible human social activity;
* adapting to student's language and culture;
* getting students to communicate issues according to their own values and interests.

The SLDP includes suggestions to teachers to encourage these aspects of duologue during the one-to-one interaction while students work at their computer terminals.

Interim Summary

With the development of the Teacher's manual, four new HCP modules, an assessment scheme for grading essays, and a new scale for writing-in-science potential for the analysis of performance, the SLDP was ready for the first extended trial. These development of SLDP are illustrated in Figure 6.3 and can be compared with Figure 5.3 which illustrated SLDP as it was used in the pilot study, and Figure 1.1 for the proposed activities of SLDP.

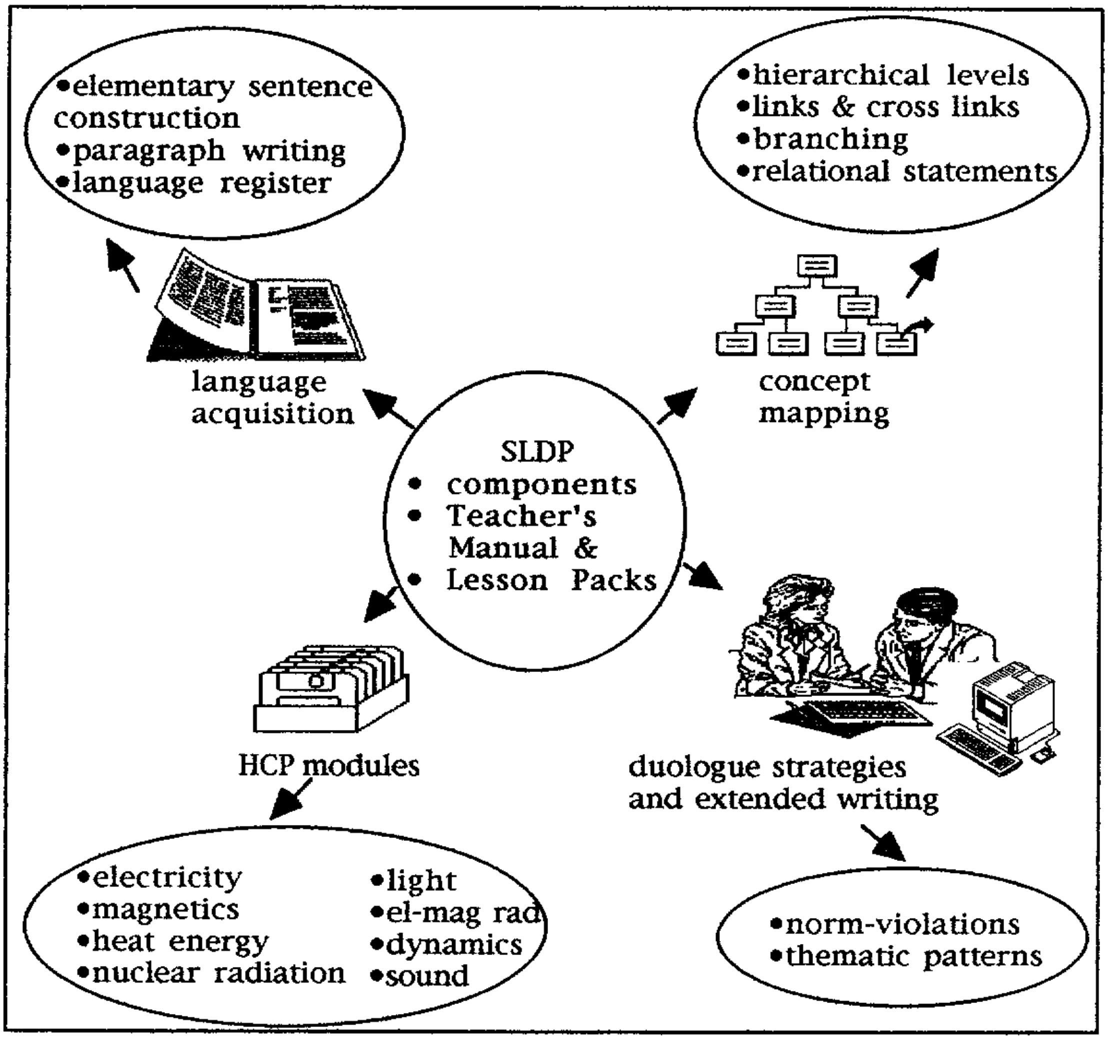

Figure 6.3. An illustration of the development of SLDP for the first extended study.

The First Extended Trial of SLDP

The first extended study was conducted in 1992 with six experimental classes, and six control classes, to investigate differences in writing performances after several uses of SLDP during a semester. As well, a seventh group of students who were attending a senior secondary college with a specialist New Arrivals Program (NAP) for non-English speaking immigrants trialled the program within their normal science course. The objective here was to investigate the effectiveness of using SLDP with English language deficient students in science classes. The results are reported separately from the results of the mainstream groups.

Sample Selection

The selection of experimental and control groups was again determined by the availability of suitable equipment in the study schools, the willingness of the teacher and school authorities to be involved, and the need to obtain a cross-section representative of year 11 physics classes.

The extended trial was conducted during second semester allowing one semester's notice to be given to the participating teachers who were thus able to integrate the SLDP into their course outlines and assessment plans for submission to the Senior Secondary Assessment Board of South Australia. The trial of SLDP was more flexible than was the case in the pilot study; the topics were more numerous; the duration of the study was more varied; and the number of study classes was greater. In addition, three experimental classes of science students in the New Arrivals Program (NAP) participated.

The procedure used to gain access to classes was similar to that of the pilot study:

(i) teachers were contacted to ascertain interest and available computer facilities;

(ii) letters were sent to the School Principal for approval;

(iii) a letter was sent to the Director General of the Education Department for approval for trials in Education Department schools;

(iv) meetings with teachers to ascertain the Physics topic required, the time available, the booking system for the computer room;

(v) meetings with the network managers to ascertain the configuration of the network, the version of HyperCard being used and printing facilities and any special requirements;

(vi) asking the participating teachers to assign an essay in the selected Physics topic two weeks before SLDP commenced;

(vii) arranging lesson times before the SLDP to give students the reading comprehension test;

(viii) finding control classes who would participate with the same Physics topic at about the same time with students of about the same socio-economic background;

(ix) arranging with teachers of control classes to assign the same essays as the experimental classes and the same reading comprehension test;

(x) making the programs for required HCP modules and *floppy discs* copied for each individual student. After the study period, results were analysed and a progress report sent to all participating teachers in the experimental and control groups.

The participating teachers were given one semester's notice and were able to integrate the SLDP into their Course Outlines and Assessment Plans for Stage 1 Physics. The experimental and control groups involved in this study are summarised in Table 6.3. Where applicable, the teacher names and alphabet characters for schools correspond to those of the pilot study and classes are designated with numerals.

Table 6.3

Experimental and Control Groups in the Extended Study

Experimental Group			Control Group		
School-class	Teacher*	Number of students	School-class	Teacher*	Number of students
A-2	Meg	8	C-2	Lynda	31
B-4	Fred	29	D-2	Myles	34
B-5	Ned	29	H-1	Alistair	11
E-1	Helen	20	I-1	Roy	10
F-1	Dan	17	F-2	Milan	15
G-1	Kev	21	G-2	Hal	17
E-2, 3, 4	Sandra	42			

* The teachers' names are pseudonyms and correspond to the pilot study.

Sample Description

The Experimental Group

Classes A-2, B-4 and B-5. These were similar in background as they came from the corresponding schools in the pilot study and were described in the previous chapter. These teachers, Meg, Fred and Ned were now familiar with SLDP and had contributed to its revision for the extended study.

Class E-1. This was a class of mature age Year 11 physics students, who were from non-English speaking backgrounds, but had qualified for entry to the class. The school was a co-educational government school that specialised with students from non-English speaking backgrounds. The students were generally from low socio-economic areas and a majority were supported by some form of government social security. The teacher, Helen, was an experienced teacher of physics, but was not competent with computers at the beginning of the study. The school was well appointed with *Macintosh* computers and printers. The network manager was most co-operative, allowing extended time to the students and assisted with computing problems. The students required more time with SLDP than the planned 12 lessons mainly because of the non-English speaking background of the students.

Class F-1. This was a class from a large co-educational government high school in a middle to low socio-economic area. The school was well appointed with physics equipment and computers and enjoyed a high reputation for its educational achievements. The network manager was co-operative to students, but little extra time could be given to them because of the time-table demands on the computing facilities. The teacher, Dan, was an experienced physics teacher and enthusiastic although not competent with computers. Dan had excellent rapport with his students and they responded quickly to the SLDP lessons.

Class G-1. This class was from a large co-educational government high school in a low socio-economic area. The computer facilities were limited in that there were not enough for one each for all students. The school was semi-open plan so that there was much movement through and around the rooms which at times was noisy and distracting. The teacher, Kev, was primarily a biology teacher and had been transferred to this school at the beginning of the semester. Kev was a conscientious teacher but did not have the confidence of the students leading to a certain amount of inattentiveness during the SLDP lessons.

The Control Group

Class C-2. This class was similar to C-1 described in the pilot study. The teacher, Lynda, had replaced Beryl on contract, and was a little unfamiliar with the school at the commencement of the semester. However, she assigned and collected physics assignments very conscientiously and assisted in the development of the SEGAS marking scheme.

Class D-2. This class was similar to the D-1 class described in the pilot study. Myles was again the teacher. However, he elected to be in the control group in this study rather than in the experimental group.

Class H-1. This class was from an all-boys' non-government school with a middle-fee paying structure. It was categorised at Level 7 on the Commonwealth Resource Index, in recognition of its medium range socio-economic clientele. Alistair was a very organised teacher with experience as Department Head. The class was highly motivated for academic achievement. The collection of writing from the students was reliable.

Class I-1. This class was from an all-girls' non-government school with a middle to low socio-economic clientele. Roy was an enthusiastic teacher with excellent rapport with the students. The students were well motivated for academic achievement. Collection of student writing was reliable.

Class F-2. This class was from the same school as the experimental group F-1 and hence a well motivated group. It was intended that the teacher Dan of F-1 would liaise with Milan about the requirements for the control group of SLDP. There were some difficulties with liaison and hence collection of student writing from Milan was minimal.

Class G-2. This was from the same school as the experimental group G-1 and had similar problems. The commitment to the assignment and collection of student writing was made by the head of department. However, the teacher, Hal, was not committed to assigning student extended writing and hence no student work was collected.

The NAP Experimental Group

The New Arrivals Program (NAP) students, in classes E-2, E-3, E-4 were studying a preparatory level of physics that would make them eligible for Year 11 the following year. They were generally older students (early to middle twenties) and had been in Australia only a short time, ranging from some months to two years. Over 90% came from non-English speaking backgrounds and oral communication was quite adequate but written language problems were evident. The teacher, Sandra, was particularly gifted and dedicated to imaginative methods of teaching. She was well supported by her faculty who expressed continued interest in the SLDP study. Written communication was a great difficulty and only a small percentage were able to gain satisfactory achievement in the WBLA. The results of these classes are reported separately from the mainstream groups.

Findings of the First Extended Trial

The potential maximum sample sizes for collection of writing pieces were from 124 experimental students and from 118 control students. The actual collection of data consisting of both pre-SLDP and post-SLDP writing, at the conclusion of the semester, came from only 73 experimental students and 16 control students. This was a disappointing collection considering the amount of preparation that was made.

Six teachers and 124 students initially agreed to participate in the SLDP extended study. Four of these teachers fulfilled the agreement to assign more than one pre-SLDP piece while the other two assigned only one writing piece, the minimum required for WBLA. The fall-off was due to a number of reasons: the physics course being arranged in semester units allowing students to transfer out of physics after one semester; some writing pieces were lost by the time of collection; the failure of some students to submit writing pieces; one teacher, Kev, transferred into school G the beginning of second semester, and only two of 21 pre-SLDP pieces of writing were recovered, hence precluding any analysis of improvement due to SLDP.

The collection of writing pieces from the control group was more difficult than it was with the experimental group for similar reasons as well as the following additional ones: one teacher, Hal, was transferred out of school G at the end of first semester and the replacement teacher had difficulty recovering the student work required; the control group teachers had a lesser degree of involvement in the research and therefore were less inclined to recover student work; it was realised later that there was inadequate feedback to the students by the researcher. These problems were redressed where possible in the second extended study described later.

After collecting all of the available pieces of writing it became evident that only a small percentage of them were written in the explanation genre. Therefore a qualitative analysis was carried out on the genres used and the distinguishing features are described here. Later, some discussion of the quantitative and qualitative results follows.

Genres of Scientific Writing Collected

The types of writing collected from 322 pieces of writing from the experimental and control groups were classified according to the general description of genres used by Martin (1990), and Hardy and Klarwein (1990) for seven genre types of scientific writing.

The Recount Genre

Biographies were assigned by all teachers for assignments and were included in their assessment plans. The objectives for these assignments were drawn from all four required assessment domains of the Senior Secondary Assessment Board of South Australia (SSABSA, 1991). The assessment schemes generally included five criteria: presentation, writing conventions observed, historical aspects, scientific aspects, and reference resources used. Normally it was expected that students would make considerable use of encyclopaedias and other reference material. Appendix 6.3a contains an example of a biographical recount which was written to the following question:

Choose one of the following physicists and research the life and work of that physicist.

The main features of this and other biographical recounts were: chronological structure (birth, schooling, inventions, honours, death); use of the past tense; use of temporal connectives rather than illatives; paragraphs were more descriptive than explanatory; scientific terminology used but not much in the way of definition; human interest included (for example the person had children, died poor, was rich, became famous, had dementia, etc.); and use of photostat pictures, drawings and other copied reference material.

The Scientific Explanation Genre Assessment Scheme (SEGAS) was developed for assessment, but it was not very suitable for assessing the recount genre of writing. However, an attempt was made to assess the amount of scientific explanation used by the students within the biography. Accordingly, these writing pieces generally were graded 'B'. Very few were graded 'B+' because this grade required development of scientific concepts through use of equations, word analogues, mathematical expressions, which were not normally met in a biography. The 'B' essays were well structured, fluent and coherent. Paragraphs were clearly designated. In a number of cases, students expressed appreciation for having found out more about particular scientists and the effects of their discoveries. The biographical recount clearly fostered interest in scientific literacy but could not be assessed in a way that was useful for this research.

Imaginative writing of reports such as *One day in the life of an electron*, were not in evidence in any of the collected material. Discussions with teachers indicated that imaginative writing was not seen as 'serious enough' for Year 11 physics.

The Report Genre

All teachers included laboratory reports as part of their assessment plans. An example of a laboratory report is contained in Appendix 6.3b. These reports satisfied criteria in the required assessment domains 1, 2 and 4 of the Senior Secondary Assessment Board of South Australia (SSABSA, 1991) with most emphasis on objective 1.1 "design investigations in physics" and 1.2 "undertake laboratory and/or field activities in physics" (SSABSA, 1991). The teachers generally marked them according to four or five criteria such as: structure and clarity of the report; presentation of results in tabular and/or graphical form; analysis of the data; discussion and relationship to theory. There was obviously heavy reliance on a laboratory manual or practical notes. Students often worked together not only on the experimental work, but also on their reports.

The features of these reports were: clear structure (aim, method results); indicative verbs; succinct phrases in note form (instead of prose and/or sentences); use of diagrams, tables, graphs, equations, mathematical expressions; limited discussion and explanation.

A second type of report genre collected was the research assignment. An example is in Appendix 6.3c. This type of writing made up 75% of assessed writing tasks. Typically the task was assigned as follows:

Use a variety of sources to research the medical or industrial or navigational aspects of ultrasonic waves. Trace the history of the development of a particular application describing the persons involved and any critical steps showing the effects that the application has had on the quality of human life.

The research assignments were assigned generally to meet objectives 1.3 "variety of sources", 3.1 and 3.2 "human and quality of life aspects", and 4.3 "communication" (SSABSA, 1991). Teachers generally used four criteria for grading: presentation: (layout, use of drawings, pictures, etc.); physics concepts and explanation; application of concepts to everyday life; use of a variety of resources. Students were encouraged by their teachers to find and use resources, to acknowledge quotations but not to copy extensive passages. They were encouraged to re-word information to satisfy the requirement for validation of students' own work.

The features of this genre were: paragraphs were structured around 'mini-topics' sometimes with sub-headings; connectives and illatives were used, especially when describing how certain instruments or machines operate; a wide range of terminology was used although explanation or definition was minimal unless specifically required by the teacher; much use of photocopied diagrams and pictures was evident; some copied diagrams were labelled by the students themselves; drafting was evident with corrections and suggestions for improvements from teachers implemented. The students generally preferred this form of writing as they could find so much information easily.

The SEGAS was not easily applied to these pieces of writing, because of the limited amount of prose writing available to assess scientific explanation and the difficulty of distinguishing the students' own explanations from that of the reference resources. For the sake of gaining some quantitative data, application of the SEGAS was done giving the benefit of explanation to the student. Thus the grading scheme usually yielded 'B' and 'A' grades. However, since much of the research assignment was copied or reworded from reference material the SEGAS would not be particularly useful for grading the research assignment.

The Procedure Genre

Very little procedure writing was evident. It was used by teachers to meet the objectives in domain1, "design investigations" (SSABSA, 1991). Some limited examples of student responses were found. The features of this genre were found to be: verb imperatives, second person pronouns, formal or informal in style such as note form, cryptic points; obvious modelling from a laboratory manual; use of diagrams and models.

The students wrote the procedure similar to the format in a laboratory manual with some obvious copying. The use of SEGAS was not applicable to the procedure genre because little explanation of the procedure was required.

The Explanation Genre

Although the explanation genre is the major form of writing required in year 12 through the external examination, very little of this genre was evident in the sample collected here. The purpose of the explanation genre is to get students to write logically in explaining the concepts and applications of physics without direct reference to resource material. This genre is particular valuable for meeting the objectives of domain 2, "understanding and problem solving" (SSABSA,1991). Students who wrote these essays for the first time without the aid of SLDP typically were graded 'C' in the SEGAS although many of these students scored well in the other genres. A typical essay in this genre is that in Appendix 6.3d which was graded a 'B' for its logical development of concepts and applications of physics and its relational aspects within paragraphs.

Two of the features of this genre were essays written without obvious reliance on resource material, and logical structure in the development of concepts and applications. This was sometimes assisted by the construction of a concept map or other planning device; structural connectives, modifying connectives, and illative connectives were used between sentences and paragraphs; linking of scientific theories, principles, and concepts with equations, laws and mathematical expressions; some hypothesising, theorising and formation of 'open' conclusions.
The SEGAS was effectively used for these essays and grades awarded generally correlated with the high, middle and low bands of the writing-in-science potential (WISP) described previously. The grading scheme was found generally to be consistent and reliable, with a small range of difference between researcher and teacher. Discussion between researcher and teacher ensured that group means and standard deviations were reliable indicators for the quantitative purposes described later.

The Discursive Argument Genre

Biggs and Collis (1989) found that an early hypothesising stage of development was reached at the transition from Year 11 to Year 12: "when students begin to question how things are and instead of accepting them from hypotheses about how they might be" (p. 156). Essays in which arguments from rival hypotheses were used indicated extended abstract reasoning. An example of an essay in this genre is included in Appendix 6.3e. However, it was generally observed that even though secondary students were capable of writing in a range of scientific genres including discursive argument genres, this genre was often misunderstood. The essays were often written in a rhetorical style, with emotive language, tricks of persuasion, and biased viewpoints. The development of discursive argument is possible with SLDP but was not the focus of this research. A different assessment scheme other than SEGAS would also be required for evaluation of the discursive argument. Such a scheme would necessarily include detection of bias, sophisms in argument, generalisations from qualified premises, and the use of sufficient evidence, precision and corroboration.

Other Genres of Scientific Writing

Examples of other genres in science writing were collected. These included a letter, a poem and an oral presentation. The letter was assigned as follows:

As an engineer your task is to write a lengthy letter to convince the builder (construction company) of a bridge that they must spend much more money on materials, as you suspect that there could be a risk of collapse in certain weather conditions with the planned construction.

An example of a response to this task is in Appendix 6.3f. An example of a poem "Aunty Jane and the Inclined Plane" is in Appendix 6.3g. Of course the applicability of SEGAS for marking these types of genres was limited to the evidence of explanation being used in the development of physics concepts.

Implementing the Trial with HCP Modules

The implementation of SLDP consisted of 12 (45-minute) lessons or the equivalent lesson time. Participating teachers were free to implement the lessons of SLDP according to their own schedules. The lessons were planned according to the implementation schedule similar to that of the pilot study, in two groups of 6 classroom lessons and 6 computer room lessons. However, in most cases the classroom lessons were transferred to the computer room and use was made of a *computer data show* or overhead projector. The 12 lesson plans were detailed in the Teacher's Manual (Appendix 6.1) and Lesson Packs (Appendix 5.2) and supplied to each teacher.

Individual double sided *double density discs* of 720K were prepared for each student. A personal meeting was held with each school network manager to ascertain the number of station requirements for HyperCard 2.0 (or 2.1), the printing facilities and the *boot-up* protocol required in each network. The HCP modules used by the experimental classes are depicted in Table 6.4. Three classes, A-2, B-4 and B-5 managed to study a second HCP module including the strategies of SLDP. The results for NAP classes are treated separately. The topic Nuclear radiation was prepared but not trialled by any of three classes.

Table 6.4
HCP Modules Used by Experimental Group

Group	Number of students	First HCP module trialled	Second HCP module trialled
A-2 (Meg)	8	Electricity	Dynamics
B-4 (Fred)	29	Electricity	Heat
B-5 (Ned)	29	Electricity	Heat
E-1 (Helen)	20	Dynamics	---
F-1 (Dan)	17	Electromagnetics	---
G-1 (Kev)	21	Magnetics	---

Pre-SLDP Writing Tasks

The pre-SLDP writing tasks were generally research assignments for formative, summative or on-going summative assessment as required for the physics course objectives and for the WBLA folio of writing pieces for moderation. To illustrate how these research assignments were assigned for the students, one example from each of the experimental classes is indicated in Table 6.5. This type of assignment produced the range of genres just described which were submitted for the pre-SLD sample. Similarly, some classes produced a second writing task. These writing tasks presented all the problems for comparative evaluation discussed previously. The assignment time was also variable as was the nature of the assessment, being either formative, summative or on-going summative, which influenced the amount of commitment given by the student.

Table 6.5
The First Pre-SLDP Writing Task

Class	First pre-SLDP writing task	Assignment time	Nature of the assessment
A-2	Research the safety features of a car and relate them to Newton's three laws	Three weeks	Summative item for physics. Eligible for WBLA
B-4 B-5	Collect at least four articles on electricity and its dangers from newspapers or magazines and present a summary of each	Three weeks	Formative item for physics. Eligible for WBLA
E-1	Essay on the advantages of science and technology	Two weeks	Eligible for WBLA
F-1	Report on the article (supplied) which has as its main theme an alternative energy suggestion	Three weeks	On-going physics summative item. Eligible for WBLA
G-1	Research some applications of science and technology in our daily lives	Four weeks	Physics formative item. Eligible for WBLA

Other pre-SLDP writing tasks were also generally research assignments. Although there were difficulties with using the SEGAS for comparative purposes, the extended study continued and student papers were collected by the teachers and copies made by the researcher.

Post-SLDP Writing Tasks

All post-SLDP writing pieces were assigned in the explanation genre, reference resources were not available for copying, and time was limited by the constraints of computer room allocation and time-tables. The purposes of the writing task also varied in accordance with each teacher's SSABSA approved assessment plan. Not all classes were assigned a second pre-SLDP writing piece and not all students were assigned a second post-SLDP writing task. The grades that were assigned were discussed with teachers prior to feedback to students. Students were told this was not their official grade but an advisory one to assist them in the writing process. All students were given an explanation about the marking scheme. In one case individual interviews were given to each student. An evaluation of the improvement from pre-SLDP to post-SLDP was done by group means.

Quantitative Results

The papers were graded according to SEGAS with grades A+ to C- for the purpose of feedback to students and teachers. Grades were converted to numerical values 1 to 9 and 'Requirements Not Met' was converted to 0, for statistical analysis. These results are called the quantitative results.

Results of the Experimental Group

A summary of the overall quantitative results for the experimental group is shown in Table 6.6 which reports the means of SEGAS scores in each of the two pre-SLDP essays and the two post-SLDP essays. The results do not indicate improved performance across the four pieces of writing. The reason offered here is the incompatibility between the two different types of writing tasks as explained above, and the difficulties of grading only the explanation parts of the writing pieces. A further complication is that not all four pieces of writing were completed by all the students. The quantitative results therefore proved inconclusive about the effectiveness of SLDP, but the exercise provided recommendations for a second extended study discussed later. The results were also analysed by WISP categories which also encountered the same difficulties. They are reported here for the sake of completeness.

Table 6.6
Results of Experimental Group Writing Tasks

	Pre-SLDP		Post-SLDP	
	First writing task	Second writing task	Third writing task	Fourth writing task
n	73	49	70	39
$\bar{x}$	3.92	3.11	3.04	3.88
(SD)	(3.10)	(1.79)	(1.93)	(1.96)

Analysis by WISP levels. The levels of WISP were assigned to 66 of the 73 students according the WISP criteria described earlier in this chapter. (The criteria did not match 7 students adequately because, for example, very high physics performance but very low language skills). Performance of the students within the levels of WISP was consistent with the total results in the experimental group. As explained above, there was the same difficulty of evaluating the improvement because of the comparison of the different types of writing. The WISP scale itself, with some modification for the second extended study, was seen as a useful device for specific analysis, as the group means of essay scores seemed to be related to the levels of WISP in all of the essays as can be seen from Table 6.7.

Table 6.7
Comparison of Writing Performance of Experimental Group by WISP

WISP category n	Pre-SLDP		Post-SLDP	
	First writing task $\bar{x}$ (SD)	Second writing task $\bar{x}$ (SD)	Third writing task $\bar{x}$ (SD)	Fourth writing task $\bar{x}$ (SD)
High	5.25	4.41	4.75	5.50
12	(2.26)	(2.53)	(1.71)	(1.77)
Middle	4.09	3.47	3.72	3.55
29	(2.38)	(1.83)	(1.85)	(2.21)
Low	3.17	0.72	2.96	3.27
25	(4.68)	(1.00)	(2.23)	(1.90)

Results of Control Group

Five teachers, not counting Hal, with 101 students, initially agreed to participate in the extended study to allow the collection of writing pieces from their physics classes in order to act as a control group in the extended study. Three of these teachers fulfilled the agreement to assign more than one piece while the other two assigned only one writing piece, the minimum required for WBLA, which precluded any analysis of improvement for this research. Again, the writing tasks were mainly research assignments and hence were difficult to score with SEGAS. An attempt was made to assess the quality of explanation, but it was difficult to distinguish the student's own explanation from that copied from resources material. The results of the assessment using SEGAS were obtained by consensus with the participating teachers. The difficulties with the range of genres presented and the variable numbers for each writing task, as described earlier for the experimental group, also applied here and hence no comparative evaluation could be made. The results are reported here, again for completeness, in Table 6.8.

Table 6.8
Results of Control Group Writing Tasks

	First writing task	Second writing task	Third writing task	Fourth writing task
n	18	6	18	0
$\bar{x}$	3.49	4.31	5.16	----
(SD)	(3.30)	(2.07)	(0.57)	

The sample size here was too small for adequate analysis by WISP. However, as it stands, the improvement from first to third writing tasks can be seen to be marginally higher than the results from the experimental group. One of the main reasons may be that the control classes generally completed all three writing tasks with the aid of references at hand, while the experimental classes were required to complete the writing task from their own concept map and with their own explanation.

The inconclusiveness of the quantitative results of the first extended study led to a greater understanding by the researcher of the genres of scientific writing and the requirements of each genre for a second extended study discussed in the next chapter. A more productive analysis of the effectiveness of the SLDP was obtained from student and teacher questionnaires and individual student interviews. These are discussed as qualitative results.

Qualitative Results

Post-SLDP Student Responses

A post-trial student questionnaire, as contained in Appendix 6.4, to assess students' opinion about the value of SLDP, was given to the students in the experimental group and responses were collected from 113 of a possible 124 students. To the first question concerning the enjoyment of the SLDP, the responses indicated that 89% (101 students) said they enjoyed the program for reasons given as being: *educational, different, fun, using computers, I didn't have to work.* The 11% (12 students) who said they did not enjoy the SLDP gave reasons such as: ***waste of time, didn't understand, don't like writing, boring.*** The enjoyment expressed by the majority of students can be regarded as an indication of a change to a more positive attitude to writing than that revealed in the pre-pilot SLDP inquiry questionnaires.

To the second question concerning the usefulness of writing to assist in the understanding of physics, the result in Table 6.9 shows that 92 students (81%), gave at least some help, while 41 students (36%) agreed that it gave much or great help.

To the third question concerning the usefulness of each of the SLDP techniques, the result in Table 6.9 indicates that concept mapping, the contextual readings and the model essays were found to be useful by approximately 70% of the students which was a more favourable response than in the pilot study to computer-assisted concept mapping. It would seem that the refinements made to SLDP for the extended study have resulted in a better understanding by students of the connection between concept mapping, reading and writing than was the case for the pilot study.

Table 6.9

Students' Perceptions of the Value of Writing and SLDP Techniques for the Understanding of Physics

Degree of assistance	Usefulness of Writing for understanding physics	Usefulness of concept mapping in HCP modules	Usefulness of contextual readings in HCP modules	Usefulness of model essays in HCP modules
No help	3	6	5	9
Little help	18	14	28	27
Some help	51	50	37	39
Much help	30	23	37	34
Great help	11	20	6	5

(n = 113)

To the fourth question concerning whether they would use the SLDP techniques again, 96 students (85%) responded positively, which was more favourable than the pilot study in which 75% responded positively. The responses to the questions concerning writing style, subject preference in which to write and the source of reference material were very similar to those of the pilot study.

Interviews with a few students from each group were also conducted some weeks after the conclusion of the SLDP period. Many of the elements already discussed were repeated in the interviews. A typical transcript of one student's interview is contained in Appendix 6.5a. Appendix 6.5b contains the corresponding student's essay and Appendix 6.5c the corresponding concept map. The interviews were conducted in a non-directional style as described by Keats (1988), in which the focus is on how the person remembers the activity rather than on the current state of the interviewee's feelings. The student was given 15 out of 20 for this essay, a personal best, from her teacher. The student recalled she had a negative attitude towards computers before the study and said she was somewhat ambivalent about personal writing ability and physics knowledge. It is obvious from the transcript that the student left this exercise with a change of attitude to writing, computers and physics. Some extracts from the transcript bear this out (I, the interviewer; S the student):

Comments about the assistance for physics:

I. You know when you did your writing, I think you were saying to me that you were so expressive that you found it a little bit hard to get the physics into it---

S. Yea, I did and then---at that stage I didn't have any physics content but I--- because of the use of the computer I could work out--structure.

I. Yes

S. and that's what I liked---I liked the concept mapping idea. I had come across that mapping idea before.

I. Have you?

S.---ahm---kinesiology---mmmmm---all of them ideas when they have a concept map you put down--- the main essay topic and then from there you just put down random thoughts---and then you make a shape out of it.

I. So you found it a good technique.

S. I liked the technique--I think that if you were taught that technique from young it would be great.

I. Yes, Yes.

S. Yea, because I mean when once you have learned it, it's very---ahm--

I. It's quick?

S. It's quick, it's, it's so obvious.

Comments about change of attitude to computers:

I. Now you have said a lot about the computer process so you liked that?

S. Oh I loved it. It's great.

I. Yes. Some people don't like using computers and others find it's quicker.

S. Well I have never used a computer until I came here. I don't even have a key card, and I ah--have never used them in the library except go up to them and get scared, and I would rather go and just ---I would even just walk around the library until I've found the books in the sections without the numbers---so I did computers--- as a course to overcame the fear of them but I hated it, so naturally they let me do what I wanted to do, not data bases and all that---

I. So did you like this program?

S. I did! This what I think computing, to me, is all about. Computing as far as doing spreadsheets and stuff is not what I am interested in and I will never do it because it is boring. But to use a computer creatively like this, so that I can get, express my words ---ahm---I think is wonderful.

Comments about the assistance for writing:

I. So It has really helped you with this essay?

S. Yea. Because if I was writing about, essay, I am really slack in my writing and my thoughts get very confused and I am very poor at spelling and I am not good at grammar either---afterwards I am OK, thinking "Oh that can have a comma" but usually I am too lazy and I think "Oh stuff it" and I will just hand it in. ---ah--- but here--- I think that because I am not very neat too, my writing is not very neat, it's not very attractive, but this is attractive.

I. Yes. It is.

S. So I got very proud of my work and then I put in the little extra touches.

These statements were typical of the majority of students who liked the program and thought that it improved their understanding of physics and writing in physics. The statements and the responses about enjoyment indicated some change of attitude towards writing in physics. Most students said they would use the techniques again, particularly computer-assisted concept mapping, if they were given the opportunity.

Post-SLDP Teacher Responses

Comments concerning the effectiveness of SLDP and its components were sought from the seven teachers (including the NAP teacher) who participated with the experimental group. The post-SLDP teacher questionnaire is contained in Appendix 6.6. The results, shown in Table 6.10, indicate a more favourable response to the computer-assisted techniques than was the case in the pilot study.

Table 6.10

Teachers' Assessment of the Value of the Components of the SLDP

Degree of effectiveness of SLDP strategies	Usefulness of the SLDP classroom lessons (sentence, paragraphs, and language register)	Usefulness of concept mapping in HCP modules	Usefulness of contextual readings in HCP modules	Usefulness of model essays in HCP modules
None	--	--	--	--
Little	2	--	--	1
Some	3	--	4	2
High	1	5	2	3
Very high	1	2	1	1

(n = 7)

The comments of the teachers are reported in full as follows:

Question 4 (Part A):

Do you think SLDP will improve your students' writing?

Comments:

Meg: *Yes. The method helped students to develop a constructive approach to writing an essay. This is of great assistance in itself.*

Fred: *It provides for some more formal "structure" for students to follow.*

Ned: *Better organisation of thoughts—arrangement of physics concepts.*

Helen: *Concept maps should mean students should "order" their learning.*

Dan: *Clarify ideas---organised approach---cut out "waffle"---investigate physics of topic.*

Kev: *Improve essays and learning of topics.*

Question 5 (A):

Do you use an itemised style of assessment as in SLDP? How do you assess?

Comments:

Meg: *No. Only a small portion of the marks are allocated to the structure of the essay. Most marks are awarded to the content.*

Fred: *No. Generally I would make a list of a number of key ideas/concepts that could be mentioned and mark according to the list. Other points also awarded.*

Ned: *No. Mixture of physics content and general "flow".*

Helen: *No, not as detailed as yours. Look for physics concepts as well as how it is written, that is, sentence structure and paragraphing.*

Dan: *No. On (my) criteria.*

Question 5(B):

In what ways could the SLDP be improved?

Comments:

Meg: *I would need much more detail on elementary sentence construction and information on how to teach or deliver these aspects to a class.*

Fred: *The program needs to be fully incorporated into the course and thus developed slowly, maybe over one term.*

Ned: *Idea of concept maps continually enforced*

Helen: *Needed more help to actually use concept maps to write essays.*

Dan: *By my being more conversant with it and "topic tightening"*

Kev: *Having a "help" menu for problems which could occur.*

Question 6:

Did you detect any differences in its use between the girls and the boys?

Comments:

No (all 6 teachers)

Question 7:

Do you think the students enjoyed SLDP? Why?

Comments.

Meg: *Yes. It was enlightening to them to be given the skills of concept mapping from which to write essays. The students liked using the computers and having model essays and reading texts available.*

Fred: *Yes. Students enjoyed working in the computer room.*

Ned: *Yes. Working with computers.*

Helen: *Yes. Most did, time to organise ideas, concept mapping.*

Dan: *Yes. Concept mapping, typing essay.*

Kev: *Yes.*

Question 8:

Comment on other aspects of the study.

Comments:

Meg: *Use of software excellent for motivation but computers need to be readily available as when not, students tended to write a draft essay at home, then draw a concept map and later key it into the computer.*

Fred: I *will be looking forward to incorporating the program fully into the course next year. Lessons 1-12 will be run over a period of a full time, only towards the end of the term would I expect students to draw up concept maps and writing essays.*

Ned: *The major difficulty seems to be the continuity of the program getting onto computers. This year it dragged on for too long. It requires dedicated teachers to allow more time in their lessons to be used on teaching and assisting students with this approach to writing. SLDP should be introduced already in Junior science courses, e. g. year 10.*

Helen: *I see concept maps as helping understand the physics but not sure if they can help your write an essay. A few students had no idea what they were doing. I could not use their final essay as part of WBLA* *as we (teachers) had given too much input ie. correcting spelling, helping with sentence construction etc.*

Dan: *Bit rushed. Wrong time of the year (our fault). Narrow topic better. Quite time consuming, but if students become comfortable with it, it greatly reduces time.*

Kev: *Operational details fiddly/time consuming to get the program started. There is still some resistance to using the concept map for writing the essay. That is, they wrote essay separately to concept map. It made it obvious which concepts were badly understood as far as the teacher was concerned. It did allow 1:1 contact and group work. It provided variety of approach. We did not have enough machines, just 12 machines.*

Question 9:

Would you use the SLDP again?

Response:

Yes: (6 of the 7 teachers)

No: (1 teacher)

Six of the seven teachers indicated they would use the SLDP program again if given the opportunity. The sixth stated that it took too much time from normal teaching. Of the six teachers, four continued into the second extended study with new classes. The other two teachers were unable to take part in the second extended study because of redundancy given to one teacher and transfer from physics teaching for the other teacher. The comments recorded above, and the informal conversations between researcher and teachers assisted in the compilation of recommendations for the second extended study. Recommendations particularly included refinements to the HCP modules to make them easier to use for the teachers and students, who were not so familiar with computer processes.

The New Arrivals Program (NAP) Results

In reporting the results of the students in the NAP program differently from the mainstream, it was possible to use other forms of assessment besides the SEGAS. Therefore, after the results using SEGAS are reported here, an example of descriptive assessment by a literacy education expert (named in the Acknowledgment) is given. Then, specific language difficulties are reported which were investigated by the researcher with assistance from an expert Vietnamese/English speaker, named in the Acknowledgment.

Using the SEGAS for Grading Essays

New Arrivals Program (NAP) students, in classes E-2, E-3, E-4, were studying a preparatory level of Physics as described earlier. Over 90% came from non-English speaking backgrounds and hence language problems were great. Oral communication was adequate and the NAP teacher was particularly gifted and dedicated to imaginative methods of teaching. Written communication was a great difficulty and only a small percentage were able to gain satisfactory achievement in the WBLA.

The SLDP program worked particularly well. There was some team teaching between Sandra and the researcher in which the researcher demonstrated the computer techniques available in the HCP modules while Sandra did most of the teaching. The program was extended to the equivalent of 18 SLDP lessons. The students appreciated a set method, such as concept mapping, to provide a bridge from heavy reliance on reference material to a personal planning structure from which they could build their own knowledge and explanation essays. The results of these students are indicated in Table 6.11. The SEGAS marking scheme was again used, but more lenience in judging adequate/non-adequate command in each of the SEGAS criteria was shown because the students were at a pre-year 11 level. These results represented a great improvement for students, most of whom had never written an extensive piece in English before. The mean of 2.23 indicated a grade of 'C'. Even though the marking was more lenient that the mainstream Year 11 classes, it was thought by Sandra that students were making better than usual progress.

Table 6.11
The SLDP Writing Performance of NAP Students

Group	Topic	Number of students	Students with Satisfactory WBLA	Mean of first essay
E-2,	light	16	7	3.12
E-3,	sound	14	1	2.79
E-4,	electricity	18	0	1.00
TOTAL		48	8	2.23

Using a Descriptive Assessment

Appendices 6.7(a, b and c) contain a student's first essay done with the assistance of a concept map, then a second essay which was done after duologue with the teacher and the improvement is obvious in the amount written, the physics concepts used, and the flow of the explanation. However, because the student had difficulties with the conventions of written English, a descriptive assessment of the second essay was obtained from the literacy expert previously mentioned. The assessment was useful to the researcher in drawing attention to the need for some further refinements to HCP modules that would enable students to correct unconventional spelling and grammar with some form of computer-assisted editing, without distracting from the main task of explaining physics concepts in a logical flow. The assessment is as follows:

> *I think (the student) knows many things about communication in general, the English language in particular and about the topic.*
>
> *He is aware of the need to structure what he wants to say and the essay has an intro, a development section and a conclusion (although he uses the conclusion as a repetitive summary). The development of his ideas is the best part of his essay because he displays a clear understanding of the principles of physics and illustrated his understanding with examples and interesting questions. His knowledge of theory and practical application are communicated, as well as the fact that he is thinking about related issues.*

He can spell some difficult words (eg. "usually", "acceleration", "collisions"). Some of his attempts to spell are phonetic (or typos?) eg. "impalse", "sosiety", and "monentum", and he is understandably confused about "brake" and "break". These are acceptable attempts to negotiate meaning.

Tense of verbs causes him problems and is a large pitfall. Can he read his work aloud? If so, he may be able to translate pauses for breath and falling intonation into commas and full stops.

I really like the sense of "engagement" with his topic (and his enthusiasm) which I get from reading this piece.

A quantitative assessment with SEGAS would have scored this essay zero and 'Requirements Not Met' for WBLA, but this descriptive assessment gives a different picture. The assessment was highly valued by the student who had just completed his first legible essay after many months of trying. This student was in a mainstream Year 11 class and naturally at a low WISP level. The student found the SLDP was a suitable technique that enabled him to get at least this far with his writing.

The HCP modules provided support for writers at the minimum level of word processing, such as using a modified *edit menu* that included *cut, paste, clear* and *style* options. Students were able to rearrange the text of their essays, to make and remake paragraph breaks, to leave space for diagrams and to choose their own presentation style using *bold, underline, italic* and any of the fonts available in the computer system folder. This enabled them to produce well presented essays of which the students felt proud. Analysis of the essays indicated that the students used this level of word processing as effectively as the other students.

At the level of using the interactive routines of planning, organising and linking, there were also no observable differences in the abilities of NAP students from the mainstream students. The NAP students used concept mapping techniques, concept selection from reading texts, and paragraph structuring as much as the other students, thus verifying the quantitative results above. However, at the level of post-writing editing for grammatical, spelling, and syntactical problems, there were obvious differences between NAP with students and others. An independent scorer was able to differentiate 84% of NAP essays from others in a sample of random mixture of essays. The differences were detected in the spelling, grammar, and syntax of the essays. The specific linguistic difficulties of the largest sub-group, Vietnamese students, were identified and are briefly summarised in the following paragraphs.

Using Duologue Strategies

Interactions between the teachers and the students were obviously constructive for concept mapping and composition of the writing task. However, no recording or evaluation was made of these interactions and hence recording and evaluation became a recommendation for the second extended study. The norm-violation aspects of duologue were particularly helpful with the NESB students, many of whom had writing difficulties. These writing difficulties are described in the next few paragraphs.

Specific Language Difficulties

A number of specific language difficulties were detected in the writing of the scientific essays. Seven such difficulties are described here.

Word correspondence. There was not a one-to-one correspondence between English words and Vietnamese words. In other words, for each English word there was not necessarily a Vietnamese word. Students may have a science background in Vietnamese, but the syntax of concepts seemed to be different. For example a battery terminal is *coc binh diên* while a positive battery plate is *tâm lăc duong,* which are unrelated phrases (Anh Viêt, undated).

Singular, and plural forms. The use of "s" for singular verbs and for plural nouns was confusing for Vietnamese students whose preference for concepts of number was for different grammatical forms.

Articles. The use of the definite and indefinite articles "the", "a" and "an" was also confusing, particularly when eliminated for the plural forms in English.

Verb tenses. The number of verb tenses was found to be limited in Vietnamese compared with English. Difficulties were experienced with the present past, and the past perfect tenses. Also, verb forms in Vietnamese did not allow differences between transitive and intransitive sentences.

Mood. The preference for the mood of verbs was that it not be expressed in the verb itself (in Vietnamese) but by an additional word for example: "maybe (in Vietnamese)" before or after a sentence.

Handwriting. Handwriting in Vietnamese, with its use of superscripts to denote different forms of the same word, became a restriction for Vietnamese students using English.

Cultural norms. It was found that there were differences between English and Vietnamese in the cultural norms of oral and written interaction. For example the use of personal pronouns can be problematic to Vietnamese students who have a background of deference according to kin relationships. For example, the use of the procedure genre with second person pronouns may present difficulties for some students.

These were some of the writing difficulties experienced by one NAP sub-group. There are different problems experienced by other groups, but more attention was given to Vietnamese students in particular because of the large proportion of Vietnamese students who chose Physics in Year 11, approximately 30% of the mainstream experimental classes and 60% of the NAP classes. One of the recommendations formulated from this experience was to attempt to design more specific word processing techniques within the HCP modules to meet specific linguistic problems.

The NAP Teacher's Comments

The comments about the SLDP program are contained in Appendix 6.8 in which the effectiveness of the SLDP was evaluated. The teacher was quite positive about the experience and volunteered to participate in the second extended study.

Summary, Conclusions and Recommendations

In response to students' and teachers' comments and from observations made by the researcher during the first extended study, several modifications were made to the HCP computer program and to the general SLDP program. Some of the problems expressed by teachers related to the meaning and use of genres in scientific writing and the requirements of each genre. This led to further discussion and refinement of the assessment criteria for the explanation genre. Clear indicators of language usage and concept development within three assessment grades were developed and included in the HCP computer modules and the Teacher's Manual. Other problems related to the computer manipulations within the HCP modules, as described below.

Limitations of the First Extended Study

The main limitation of this extended study was the difficulty of measuring the improvement of experimental group compared with the improvement of control group. Although the marking scheme, SEGAS, was used for assessment of all pieces, the data yielded inconclusive results. It was clear that performance in research assignments was better than in the experimental essays. It was only during the first extended study period that this became apparent. Other genres, although validated as student work, relied heavily on resource material, drafting processes and external assistance and therefore could not be used for comparative purposes.

The sample of writing pieces collected from the control group was much smaller than anticipated. It was difficult to recover prior student work. The conclusion is that clearer directions to participating teachers were needed and that the researcher should be present for the collection of student work at the time it was being done. Another conclusion was that more involvement of the researcher with the control classes would assist in generating a higher percentage of control group responses. Personal feedback of grades, an explanation of the SEGAS scheme and some interviews with students in the control classes were planned for the second extended study.

The second limitation was the lack of assessment of the *navigational pathways* taken by the students in demonstrating the full use of HyperCard capabilities. It was planned to refine the HCP modules in such a way to facilitate greater use and awareness by students of the *navigational pathways* capabilities. It was also planned to make an assessment of *navigational pathways* used by students in the evaluation of the second extended study.

A third limitation of the first extended study was its focus on physics at the year 11 level. It was planned to explore the possibility of using SLDP for chemistry or biology essays at the Year 11 level.

Problems with HCP Modules

The following problems emerged with the HCP modules used in the first extended study. They were to be rectified for the second extended study.

Printing problems. Initially the *file menu* was hidden. This meant that the teacher had to reset the *menubar* manually for each student to print the *card* for a concept map or *field* for an essay. In some schools low memory machines could not print the maximum size concept maps which were made by *scrolling* within the *screen window.* Another problem was that laser printers were very slow with printing the *cards* of concept maps. Students were disappointed with these delays.

HyperCard *userlevel* problems. The HyperCard *userlevel* in some schools was set too low (*userlevel* 4 is required) by *default.* This necessitated manually checking and changing it when needed. This caused much difficulty when there was no time between classes scheduled to use the computer room. The teacher needed time to reset HyperCard for each machine in turn to access the network, and this caused a waste of time and restlessness in some classes.

Network and system problems. The use of HCP modules on a *AppleTalk network server* caused considerable time delays, particularly with low memory machines. The network managers had an undue amount of preparatory work such as creating a *new folder* at each station in which dedicated access to HyperCard had to be made; locking the application at the *Finder level* for multiple user access; resetting system memory; and others. The printing of cards and fields was also extremely slow on *AppleTalk* network system software version 6 or 7 and HyperCard version 2.0 or 2.1 were also necessary. Low memory machines such as *Macintosh Plus* could not access the *tool pallet* which soon stopped concept mapping.

No short-cut access to various parts of the module. When students were well into the sequence of 12 lessons, they had to start each time at the beginning of the program and manually go forwards through each card. While this could be seen as a good revision exercise, it was somewhat time consuming and boring to the students.

Limited word processing. The problems here were partly caused by the hiding of the *edit menu* from the regular *menubar* causing *cut* and *paste* options to be unavailable to the students. This could be overcome by resetting the *menubar.* However, a further intrinsic limitation is the lack of spelling checking or grammar checking programs. These two programs would greatly improve students' essay writing.

Recommendations for the Second Extended Study

It was realised that the main problem of lack of scientific explanation genre essays could be alleviated if a number of experimental and control teachers agreed to assigning four similar essays. The essays needed to be of explanation genre aimed at meeting objectives in domains 3 and 4 of the Extended Subject Frameworks (SSABSA, 1991). The other writing tasks such as research assignments, laboratory reports and biographies, were still necessary for the teacher to meet other course objectives, but they were not to be included in the Second Extended Study of SLDP because of the difficulty of making valid comparisons between the various genres of writing. The titles of the essays needed to be carefully worded. The first recommendation from this extended study was that: writing tasks be assigned in the explanation genre; writing tasks be assigned that allowed students to develop their ideas with the use of language indicators of coherence and scientific expressions for the logical development of concepts. Such a list of essay writing tasks for the explanation genre is contained in the Appendix 6.9.

A second recommendation was that similar arrangements be made between experimental and control groups for such things as: the wording of essay titles, the duration of the assignments, validation of students' own work, the relative importance placed on the assessment of each essay in both experimental and control groups; a means of providing feedback to control group students comparable to that being given to the experimental students.

A third recommendation was for total integration of the techniques of SLDP into the teachers' courses of study, rather than as a separate 12 lesson program. In this way elementary sentence construction, paragraph writing, and use of language registers were to be part of all lessons, not just a special six lessons of the SLDP program.

It was seen from the collection of essays in the first extended study that the bands of WISP indicators needed to be expanded. Within the middle potential group, there were some students who scored highly in physics but poorly in English, others who scored highly in English but poorly in

Physics. There were those who were good in both physics and English without being outstanding in either, and those who performed poorly in both, but were not part of the 'low WISP' group. It was planned to design a seven-band scale of WISP.

Analysis of how the teachers used the Teachers' Manual and the HCP modules, and the usefulness of a lesson pack of overhead transparencies resulted the following recommendations for the second extended study.

The Teacher's Manual required the following editing and additions: specific lesson plans for 12 lessons arranged for easy access in the Teacher's Manual; the addition of a new chapter for trouble shooting in case of difficulties with the HCP modules; the addition of a new chapter for advanced use of the HCP modules to enable teachers to adapt the program to their own topics.

The classroom use of the HCP modules was observed and comments from teachers noted. It became apparent during the first extended study that personal dialogue (duologue) between a teacher and a student during the use of the HCP modules was an important element in the effectiveness of the SLDP. The recommendation for the use of as much dialogue as possible was included in the induction of participating teachers in the second extended study.

Lesson packs for each physics topic were necessary to assist the teacher in preparation for the HCP module in that topic and for the integration of the other elements of SLDP into their general teaching techniques. A recommendation that separate lesson packs be made for each topic in the HCP module was carried out.

A further recommendation was that the SLDP be extended to chemistry and biology by teachers with some familiarity with HyperCard, and that essays be collected as part of the experimental sample. The assessment of essays was to be to be made with the SEGAS similar to the physics essays.

CHAPTER 7
THE SECOND EXTENDED STUDY

Introduction

This chapter reports the second extended study undertaken to further investigate the third research question concerning the general effectiveness of the SLDP, and to investigate the fourth research question concerning the effectiveness of SLDP in terms of specific elements of the definition of scientific literacy: activating the cognitive processes, engaging in the discourse of science, and communicating a form of language register of science, for scientific literacy. The design was a repeated measures trial of SLDP with assigned writing tasks. The four writing tasks were assigned over the full period of one academic year. Classes in the experimental group were assigned two pre-SLDP writing tasks and two post-SLDP writing tasks. Classes in the control group were assigned four writing tasks at similar time intervals but without assistance from SLDP. The student writing tasks were collected, assessed, and returned to students with feed-back concerning the assessment. The SEGAS, developed in the first extended study and subsequently published, see Cronin, Brown, and Pollard (1993), was again used for assessment of writing pieces. The grades were assigned by the researcher in conjunction with each participating teacher. The results were then analysed for general improvement in writing and for effectiveness in regard to specific elements of the definition of scientific literacy.

Four of the seven teachers who participated in the experimental group of the first extended study undertook to take part in the experimental group of the second extended study. Four of the six teachers who participated in the control group of the first extended study undertook to be part of the control group in the second study. For two of the experimental group teachers, Meg and Fred, this was their third year with the project and they had incorporated the components of SLDP into their course schedules. A copy of Fred's course schedule is contained in Appendix 7.1 as an indication of the viability of incorporating SLDP into the Year 11 course schedule, a sub-question of the third research question.

The developments and refinements to SLDP for the second extended study are first discussed followed by the description and findings of the second extended study. The chapter concludes with a report of some post-study developments and summary.

Further Developments and Refinements of SLDP

Improvements

Prior to beginning the second extended study, a number of improvements were made to the SLDP in accordance with the recommendations derived from the first extended study.

Teacher's Manual

To facilitate the independent use of SLDP by teachers, the Teacher's Manual was revised and two new sections were added: a trouble-shooting section for use with HCP modules, and an advanced users' section for those with some skills in HyperCard. Both of these two sections are illustrated in the revised Teacher's Manual in Appendix 6.1.

Trouble-shooting. The 'Trouble-shooting' section provided remedies for nine problems encountered by students during the previous trials such as not finishing erasing, unintentional resizing and some printing problems. Trouble-shooting allowed teachers to rectify quickly the problems that students encountered, usually from incorrect manipulations of either the computer or HyperCard.

Advanced skills. The 'Advanced skills' section enabled teachers to modify the HCP modules to suit their own purposes. This allowed teachers to add new definitions, new contextual readings, new model essays, new cards or new stacks, and eventually to design new HCP modules. This could be done by teachers with minimal competence in HyperCard. A further supplement to the Teacher's Manual contained the directions for modifying the spelling checker, grammar checker, and the document statistics counter in the editing menu for essays. This supplement is contained in Appendix 7.2.

Lesson packs. Lesson packs were refined and supplemented with two new lesson packs for chemistry: metals, and acids. The lesson packs proved valuable to the teachers who were trialling the SLDP for the first time. The experienced teachers had developed their own lesson plans to incorporate the components of SLDP into their course schedules.

Student-teacher Duologue

During the HCP lessons there was much opportunity for student-teacher duologue, a necessary component in the development of scientific literacy. The participating teachers were encouraged to engage with the students in the duologue strategies of Lemke (1990), such as norm-violations and setting thematic patterns, thus enabling students to speak confidently in some form of language register of science.

Audio recordings were made of some of the duologue between student and teacher during HCP activities to gauge the extent of the duologue and to analyse how thematic patterns emerged according to the theory of Lemke (1990). Audio recordings were also made of regular classroom dialogue in order compare the patterns of dialogue with those in the regular classrooms. This is reported in the discussion on results.

Refinements to Existing HCP Modules

Selection of genre. This enabled students to choose the explanation genre as one of the genres, as shown in Figure 7.1.

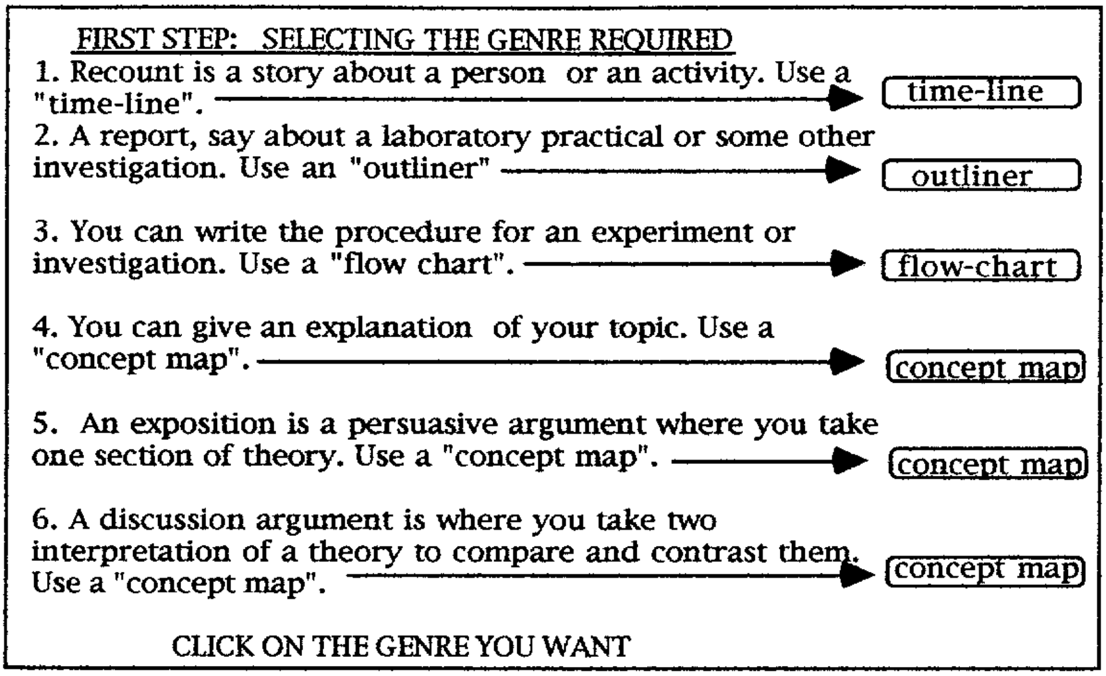

Figure 7.1. Selection facility for computer-assisted genre scheme.

Pop-up definitions. A new *card* containing the definitions of the concepts listed in each HCP module was added. The definitions are in *hidden fields* which can be accessed by means of card buttons. *Pop-up* definitions are included for each of the concepts as an introduction to concept mapping. The students can navigate quickly from any part of the module to the *Pop-up* definitions and then return to the exercise at hand, as shown in Figure 7.2.

Navigation pathways. This refinement provided better navigation pathways so that students might more easily choose from a number of ways how to proceed: step by step, backtrack, jump to different sections, go to the start, go to the end, or quit at any point in the program as shown in Figure 7.2. The printing facility of concept maps and/or essays is within an edited *file menu.* The *script* provides *read-only* texts in *locked fields* and provided *unlocked fields* for essay composition and concept mapping.

Additional *stack* of concept maps. An additional stack for up to eight different concept maps was provided in each HCP module, with the possibility of adding further cards if required for further essays or summaries as required by the students. Navigation pathways were created to the current concept map from other places in the module similar to the Figure 7.2.

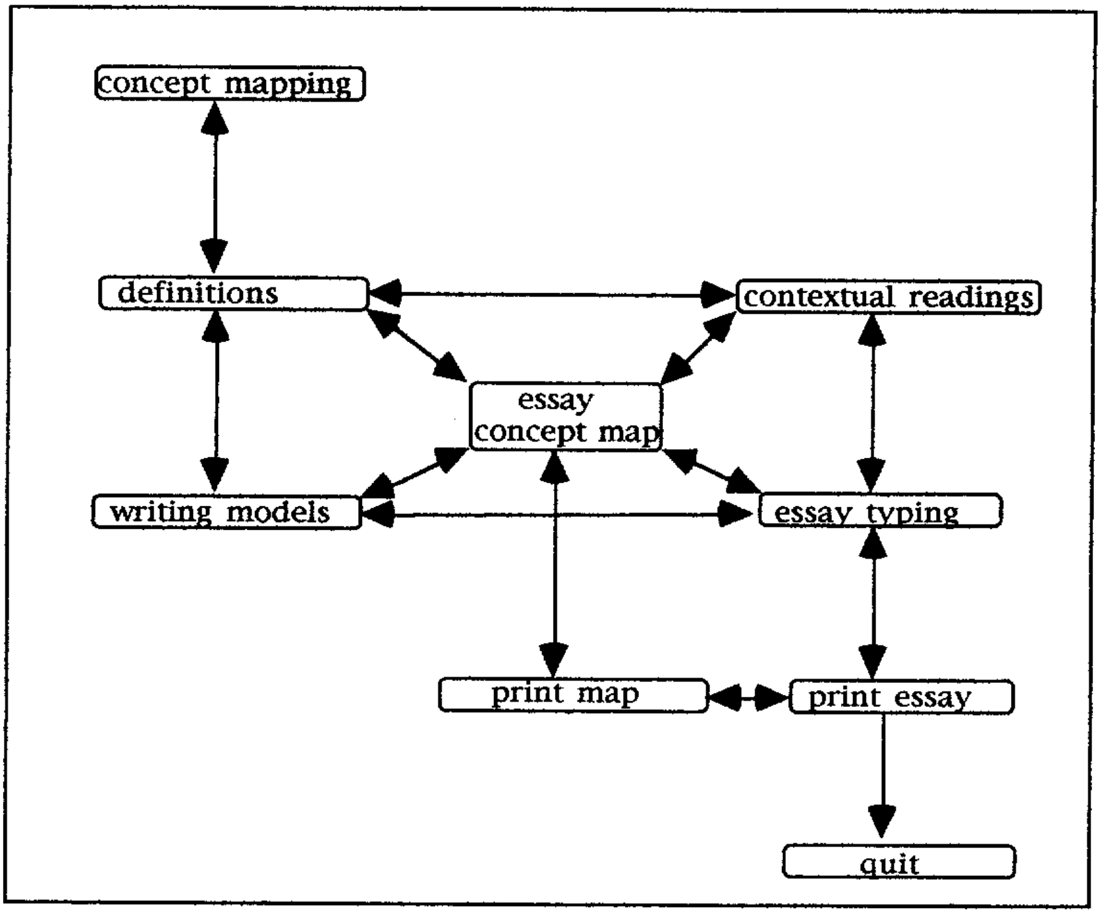

Figure 7.2. Some possible navigational pathways within HCP modules.

Keyboard shortcuts. Some of the keyboard strokes were modified for simpler use by students. Certain keyboard strokes in HyperCard had different effects from those of word processing software packages. For example, the *tab* key selected all text in an *unlocked fields* in which a student was composing an essay. The very next keystroke deleted the whole field, causing some consternation to the student! There was no *undo delete* command available in HyperCard. Students thus would lose an entire essay from a simple miss-key stroke. The *up* and *down arrow* keys in the standard HyperCard sent the program to other stacks, which again caused problems. This was rectified by *scripting* the *disable* command into each HCP module. The *left* and *right arrow* keys were left as short-cut keystrokes to move from card to card.

Improved print style options. The print style options were left in the *edit menu* for essay tying. In this way students could use different print *styles* and *fonts*, for example in special formulas.

Editing facilities. The principal limitation of the standard HyperCard program was that it offered only very limited text editing facilities. These were elementary word processing facilities, but no syntactic or semantic guides were provided. Therefore, the development within HCP of spell checking for the specific Physics topic, and grammar checking for specific difficulties that have been identified were gradually developed throughout the second extended study, and are discussed later in this chapter. These checking facilities enabled students, particularly those from non-English speaking backgrounds, to address some of their language acquisition problems. The checking was by prompt only, so that students did not lose control of, or the responsibility for, their own text.

New HCP Modules

Two modules were written in chemistry topics in response to the recommendation from the first extended study to investigate the possibility of using SLDP for topics other than in physics. A list of topic concepts, concept definitions, relational statements, contextual readings, and concept mapping exercises were developed for each new module. Each module was developed for a four week period for the Year 11 course. A complete reference list for the contextual readings is contained in Appendix 7.7 as well as in the HCP modules with acknowledgment for permission to use these extracts.

Acids in Pollution

Concepts: ions, cation, theories of acids, pH, oxides of N, oxides of S, proton, acids, pollution. *Pop-up* definitions are included for each of the concepts as an introduction to concept mapping and can be accessed from any part of the module.

Relational statements: has, used, is a an example of, contains, belongs to, is measured by, is the property of, causes, for, and, nor, because, or, yet, so, by analysis, by balancing atoms, by neutralisation, by balancing charges.

Contextual readings: Red spot disease, the acid connection, from Ecos, 70; Metals, muck and magnets, from Ecos, 67; Ozone layer, from Ecos, 69; Formic acid in the top end, from Ecos, 50; Carbon dioxide, from Ecos, 28; Acid in the body, from Exploring Science, Stannard & Williamson (1981); Acidic water, from Ecos, 70; Acidity of Sydney's rain, from Ecos, 34.

Metals

Concepts: reactivity, cation, electrical conductivity, heat conductivity, magnetism, Cu, Fe, steel, orbitals, octet rule, theory of periodicity. *Pop-up* definitions are included for each of the concepts as an introduction to concept mapping and can be accessed from any part of the module.

Relational statements: has, used, is a an example of, contains, belongs to, is measured by, is the property of, causes, for, and, nor, because, or, yet, so, by sequence of levels, by quantum numbers, by Pauli exclusion, by octet rule.

Contextual readings: Gallium arsenide, from Genesis, 9(1); Measuring the impact of lead, from Ecos, 71; Legacy of heavy metals, from1988, Ecos, 55; Chemtronics, from Ecos, 56; Superconductivity, from Ecos, 59; Lead in the skin, from Ecos, 60; On a sheep's back, from Ecos , 73; The iron age, from Asimov's New Guide to Science, Asimov (1984); The bronze age, from Asimov's New Guide to Science, Asimov (1984).

Extension of the Writing In Science Potential (WISP) Scale

The WISP scale developed in the first extended study was expanded from three categories (high, middle, and low) into seven to allow a more detailed analysis of results. The seven categories are called 'bands' in this chapter. The seven bands of WISP cater for more detailed literacy skills as described in Table 7.1. A range of independent results for the reading/writing ability of students similar to that used in the first extended study was again employed. The semester English mark was also included. This allowed the group of students who were high achievers in physics but not so high in English (band 3) to be distinguished; likewise, those who were high achievers in English but not so high in physics (band 4). There was also the group who were below average either in physics or English but not both (band 6). The low achievers (band 7) were distinguished as previously by having difficulties with WBLA as well as with physics and English. These bands of WISP are used in the discussion of results later in this chapter.

Table 7.1
The Seven Bands of WISP

		Criteria			
WISP band	Description of band according to WISP	Writing Based Literacy Assessment	TORCH stanines	Semester Physics grade/ mark	Semester English grade/ mark
1	High grades in physics, English and high literacy	Satisfactory	8 or 9	A/17+ to 20	A/17+ to 20
2	Moderately high grades physics, English and literacy	Satisfactory	7 or more	B/14 - 16	B/14 - 16
3	High grades in physics and lower grades in English	Satisfactory	7 or more	A/17+ to 20 or B/14, 15	C/ 12, 13
4	High grades in English and lower grades in physics	Satisfactory	7 or more	C/ 12, 13	A/17+ to 20 or B/14, 15
5	Middle grades in physics, English and literacy	Satisfactory	5, 6	B/14, 15 C/ 12, 13	B/14, 15 C/ 12, 13
6	Middle grades in one of physics, English or literacy	Satisfactory	5, 6	B/14, 15 C/ 12, 13	B/14, 15 C/ 12, 13
7	Low grades in physics, English and literacy	Require-ments Not Met	<5	D/<12 or less	D/<12 or less

Interim Summary

The further developments of SLDP made it ready for trial in a second extended trial. An illustration of this fuller development is depicted in Figure 7.3 and can be compared with the previous model of SLDP illustrated in Figure 6.3 for the first extended study and Figure 5.3 for the pilot study.

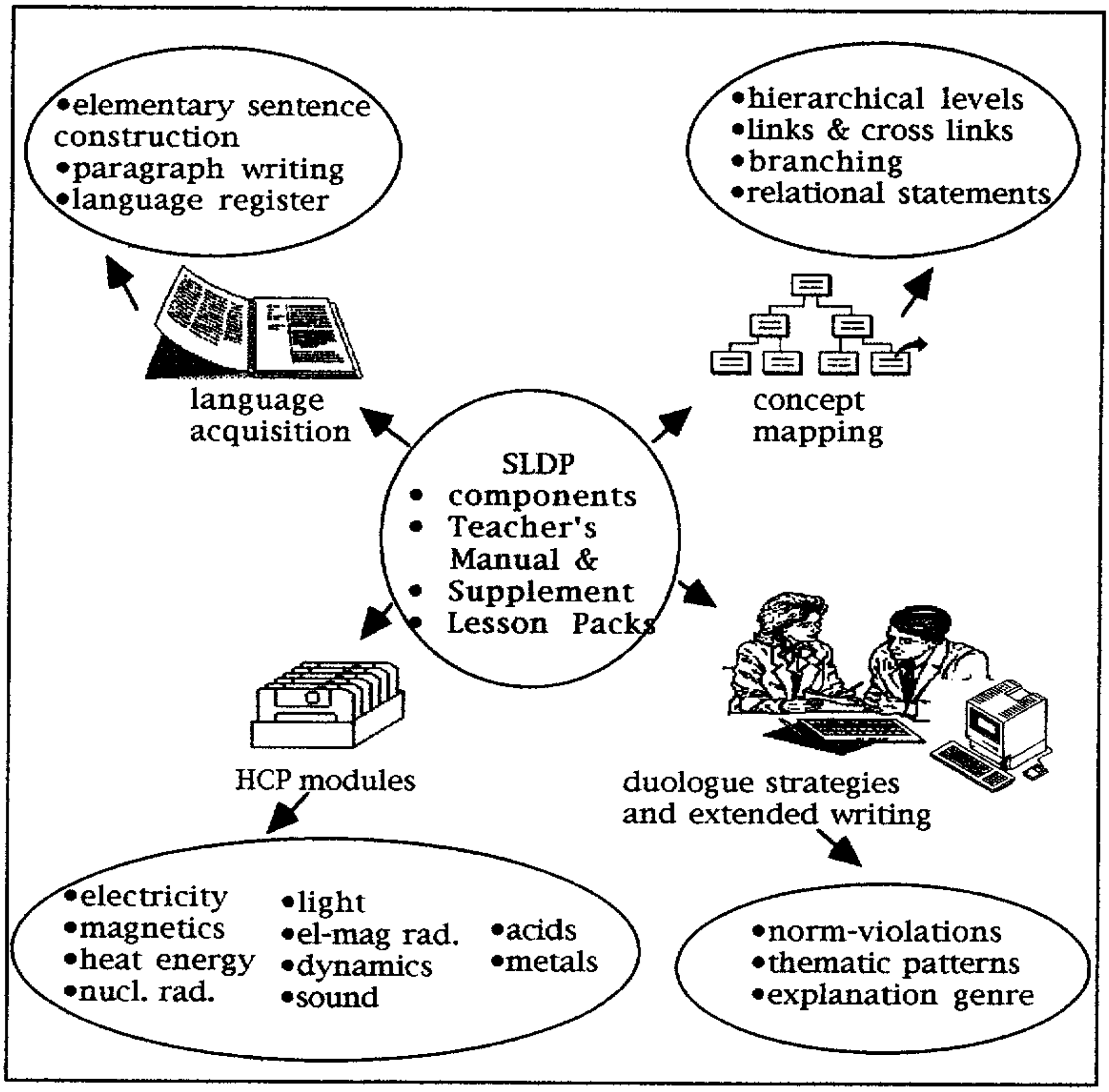

Figure 7.3. An illustration of the expansion of SLDP for the second extended trial.

Sample Selection

The sample of experimental and control groups was again determined by the availability of suitable equipment in the trial schools, the willingness of the teacher and school authorities to be involved, and the desire to obtain a representative cross-section of year 11 physics classes.

The second extended study was conducted during two semesters allowing the participating teachers to integrate the SLDP into their course schedules and assessment plans for submission to the Senior Secondary Assessment Board of South Australia for the academic year. The sampling resulted in eight experimental classes from seven schools and five control classes from five schools. This sample initially provided numbers of 188 students in the experimental group and 114 in the control group. A special group of NAP students again used SLDP and results are reported separately from those in mainstream classes. The procedure to gain access to classes, as described in the previous studies, was again observed.

The experimental and control groups that participated in the second extended study are reported in Table 7.2. Where applicable, the teacher names (pseudonyms), and the alphabet characters for schools correspond to those of the pilot and first extended studies, while classes are designated by the numerals. In the sample there were four new teachers: Phons, Liam, Guy and Vic, in the experimental group, and one new teacher, Kylie, in the control group.

Table 7.2
Experimental and Control Groups in the Second Extended Study

Experimental Group			Control Group		
School-class	Teacher*	Number of students	School-class	Teacher*	Number of students
A-3	Meg	17	I-2	Roy	16
B-6	Fred	26	D-3	Myles	23
B-7	Fred	32	H-2	Alistair	28
F-3	Dan	21	F-4	Milan	23
G-3	Phons	11	G-5	Kylie	24
J-1	Liam	30			
K-1	Guy	27			
K-2	Vic	24			

* The teachers' names are pseudonyms and correspond to previous trials.

Sample Description

Experimental Group

Classes A-3, B-6, B-7, F-3, G-3. The classes A-3 (Meg), B-6 (Fred), B-7 (Fred), F-3 (Dan), and G-3 (Phons) were similar to the corresponding classes described in the first extended trial. The teachers Meg, Fred and Dan were familiar with SLDP. It was the first time use for teacher Phons, and the first use of SLDP with chemistry topics. The chemistry topics trialled were: the effect of acids in pollution, and the extraction and refinement of metals. Phons was head of the science department and an experienced teacher of chemistry. Phons was enthusiastic about trialling new pedagogical methods and organised a workshop in SLDP for other teachers in the science department. The difficulty for Phons was that the school computer equipment, time-tabling, and access to the equipment presented major difficulties as had been the case in the previous year for Kev (G-1).

Class J-1. This was from a large co-educational government high school situated in a low to middle socio-economic area. The school was well supplied with equipment including *Macintosh* computers. The teacher, Liam, was able to arrange convenient access for the SLDP lessons and the students responded favourably. Liam was an experienced physics teacher, and was initially concerned about the time to be spent on the program. He had no previous experience with computers or concept mapping or language development, and so was interested but wary of possible waste of teaching time. The network manager was cooperative in ensuring that the HCP modules operated smoothly.

Classes K-1, K-2. These classes were from the same school, with teachers Guy and Vic respectively. The school was a large co-educational non-government school with a low to middle socio-economic clientele. The school was well appointed with physics equipment and *Macintosh* computers. The students were familiar with the use of computers. Guy, the senior physics teacher, was highly competent with computers. Vic, was a less experienced physics teacher but had used concept mapping regularly as a teaching strategy. Both Guy and Vic were enthusiastic about the trial and incorporated it into second semester course schedules. This posed some problems by the end of the year as the pressures of examinations, reporting and interviewing caused some curtailment of the program and the time devoted to it.

Control Group

Classes I-2, D-3, H-2, F-4. These classes I-2 (Roy), D-3 (Myles), H-2 (Alistair), and F-4 (Milan) were similar in background to the corresponding classes from the same schools described in the first extended study. The teachers, Roy, Myles, and Alistair, were familiar with the procedure for collecting essays and returning them to the students. The change for them in this second extended study was that the writing tasks were more specific and more class-time was required for feedback to students. These aspects of the trial are discussed later. The involvement for Milan was greater in this trial, because of the establishment of direct contact between him and the researcher compared with the indirect contact (through teacher Dan) in the previous trial.

Class G-5. This class (Kylie) was similar in background to class G-3 and was also a chemistry class. The initial agreement with school G was to have a class, G-4, with teacher Herb and 19 students. However, Herb was transferred after approximately five weeks; then Kylie was asked to participate as at that stage she had a parallel Year 11 chemistry class. Kylie was a late transfer to the school and had not been involved in the planning of the SLDP trial and although she was co-operative, difficulties arose later with the assignment of writing tasks in the genre required and with subsequent collection of data. For example only five of the first essays could be recovered from the first assignment set by the previous teacher, Herb.

Sample Mortality

The sample mortality in this study is regarded as the percentage of students from whom it was not possible to collect four pieces of writing according to the specific writing task required for this second extended study. The repeated measures required that only those students who completed the two pre-SLDP and the two post SLDP essays and the control students who completed all four essays during the trial period could be considered for comparison. The collection from students of four pieces of writing in the scientific explanation genre within the two semester period, provided the data for the quantitative evaluation of SLDP. The number of collected pieces of writing is depicted in Table 7.3.

Experimental group. From 188 students initially in the experimental group, 103 students produced four pieces of writing in the required genre. The four pieces were two pre-SLDP and two post-SLDP and although this represented 55% of the initial number of students, the collected data were from all schools and represented all bands of WISP. A number of reasons for this sample mortality rate can be given. For example, a number of students withdrew from physics at the end of the first semester. This reason applied particularly with group A-3 (Meg) in which 11 of the 17 students transferred out of physics. This was an option made possible by the introduction of semester length courses and the curriculum structure of the school. Other reasons were that some students did not complete one or more of the assignments over the two semester period, and others could not, or perhaps chose not to, provide copies of essays to the researcher. Thus it was possible to collect four pieces of writing from only 103 students for the quantitative analysis.

Control group. From 114 students initially in the control group, 49 students produced four pieces of writing in the explanation genre. One teacher, Myles from control group D-3, assigned only two pieces of writing of the required genre within the two semesters because of personal work overload. Teacher Kylie from control group G-5, was a late replacement teacher and was not committed to assigning four essays of the explanation genre. She set research assignments which could not be used for analysis in this stage of the research as explained in the previous chapter. The collection of four essays from the control classes represented 43% of the initial numbers and the reasons for this sample mortality were similar to those of the experimental group. The essays came from three schools and represented six of the seven bands of WISP. Thus it was possible to use the four pieces of writing from 49 students for the quantitative analysis. The collection number of each of the essays is shown in Table 7.4.

Table 7.3
Data Collection from the Experimental Group

Experimental Group	First essay	Second essay	Third essay	Fourth essay	Number of students supplying four essays
A-3 (Meg)	17	17	6	6	6
B-6 (Fred)	29	29	30	25	21
B-7 (Fred)	25	20	22	21	18
F-3 (Dan)	20	21	19	18	11
G-3 (Phons)	8	8	8	7	6
J-1. (Liam)	29	26	26	19	16
K-1 (Guy)	27	21	23	17	15
K-2 (Vic)	25	23	23	15	12
TOTAL	180	165	157	128	103

Table 7.4
Data Collection from the Control Group

Control Group	First essay	Second essay	Third essay	Fourth essay	Number of students supplying four essays
I-2 (Roy)	16	16	14	11	10
D-3 (Myles)	17	22	-	-	0
H-2 (Alistair)	27	27	27	23	23
F-4 (Milan)	22	23	23	18	16
G-5 (Kylie)	5*	21	19	-	0
TOTAL	87	109	83	52	49

* Recovered from assignments for previous teacher, Herb.

Implementation of First Study Recommendations

Specific Writing Tasks

In accordance with the recommendations from the first extended study, teachers were asked to set all writing tasks in the explanation genre. A list of suitable essay questions (contained in Appendix 6.9) was given to all experimental and control group teachers at the time of preparation of their 1993 physics course schedules and assessment plans. The essay questions were composed according to the advice of Whitehouse and Sullivan (1992) for explanation genre essays. The essay questions required students to 'explain', 'give a reason', 'give an explanation for', or 'discuss' in contrast to a writing task with instruction words such as 'what', 'which', 'list', 'name', 'describe', which did not signal to students the requirement for explanation.

Also the teachers were asked to apply similar conditions for the performance of each task and its assessment. In other words, each writing task was to be a summative or on-going summative assessment for inclusion the Teacher's report of physics grades.

Teachers were asked to allow students two weeks for the completion of the writing task and to make it clear to students that the writing tasks for

SLDP were to be essays of explanation and therefore were different from research assignments which required more descriptive detail. There were other writing tasks required by Senior Secondary Assessment Board of South Australia (SSABSA, 1991) apart from this study, and hence the commitment to four essays was a major undertaking by the experimental and control group teachers.

Feedback to Control Students

Again in accordance with the recommendations of the first extended study, the researcher kept in continual contact with all experimental and control group teachers. The collection of student work was made as close as possible to the completion date and many school visits by the researcher were required to achieve the maximum collection of student work. The researcher then gave personal feedback to all control group teachers and students generally within one week of the collection of student work. The feedback was in the form of an assessment grade using SEGAS as well as by written comments about the essay with individual discussion and class discussion. The control group students were informed that their work was part of research into scientific explanation essays. The control group students were given approximately the same amount of feedback, time, and discussion of their essays as were the experimental group students. This ensured a greater commitment by the control group students to the study.

A further recommendation from the first extended study was for the extension of the trials to science subjects other than physics. This was done with experimental group G-3 and control group G-5 in chemistry.

Findings of the Seconded Extended Trial

The findings of the second extended study are reported here under three headings: first, the quantitative analysis for general improvement in scientific writing; second, the multivariate analysis of variance; third, the qualitative analysis of the trial; and fourth, the specific analysis in terms of the elements of the definition of scientific literacy. These analyses triangulate the results to determine the effectiveness of SLDP.

Quantitative Analysis

The quantitative analysis of general improvement on students' essays began by using the SEGAS and then converting the grades to scores, ranging from 0 to 9, in the same manner as in the first extended study. The SEGAS grades were assigned independently by the researcher and validated with the participating teachers for each class. Feedback was then given to students using the descriptors of the SEGAS criteria to explain the reasons for the grades allocated.

The results expressed in group means and standard deviations for the total collection of essays are depicted in Table 7.5. The students from whom all four essays could be collected was less than the number from whom a fourth essay was collected, as not all those completing the fourth essay had completed all other three essays.

Table 7.5
Results from the Total Collection of Essays

	Experimental Group			Control Group		
	n	$\bar{x}$	SD	n	$\bar{x}$	SD
First essay	180	2.66	1.80	78	3.14	1.94
Second essay	165	2.68	1.86	79	3.56	2.42
Third essay	157	3.94	1.86	63	4.53	2.07
Fourth essay	128	5.29	1.95	51	5.25	2.23

However, in order to analyse the data according to the time-series repeated measures design, only those scores from students who completed all four essays were used in the quantitative analysis. The means and standard deviations of these scores are shown in Table 7.6. It is clear that these means and standard deviations show trends comparable to those of the total. The means are greater due to the higher number of non-collection of essays from the weaker students. The trends in scores for the experimental and control groups reported in Table 7.6, are illustrated in Figure 7.4. This graph was drawn from the data of the four separate essay scores from the experimental and control groups. The time interval between essays varied as each teacher planned assignment times differently, but the four tasks were dispersed reasonably evenly throughout the year.

Table 7.6

Comparison of Mean Scores of Students Completing all Four Essays

Group	First essay $\bar{x}$ (SD)	Second essay $\bar{x}$ (SD)	Third essay $\bar{x}$ (SD)	Fourth essay $\bar{x}$ (SD)
Experimental	2.92	2.76	4.32	5.24
n = 103	(2.07)	(1.85)	(2.05)	(1.87)
Control	3.37	3.82	4.86	5.20
n = 49	(1.94)	(2.45)	(1.99)	(2.21)

These data are shown graphically in Figure 7.4 in which the differing trends of improvement between the experimental and control groups can be compared easily.

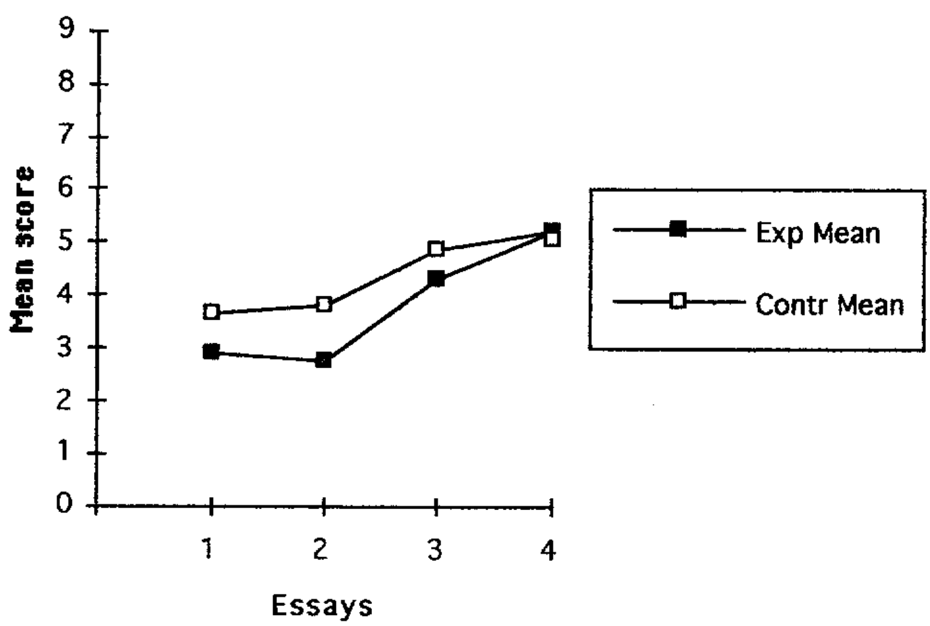

Figure 7.4. The comparison of essay mean scores of experimental and control groups.

The change in means from first essay to fourth essay over two semesters indicates a trend of general improvement for both the experimental and control groups. The comparative trend of general improvement is used here to give an indication of the general effectiveness of SLDP. This improvement is analysed in more detail later in the chapter, and relates to specific elements of the scientific literacy definition.

Even though the means for first and second essays of the experimental group are less than those of the control group, the general improvement appears to be greater, as can be seen from Figure 7.4. The largest improvement seems to coincide with the intervention of SLDP after the second essay. No such rapid change after the second essay seems evident in the control group for the experimental group, in which a reasonably steady improvement across all four essays is seen. This steady improvement is to be expected considering that over the period of the academic year, maturation occurs, increased knowledge of physics takes place for most, and students become more familiar with the assessment requirements.

Multivariate Analysis of Variance

To examine whether there was a significant difference in improvement between the experimental and control groups, a multivariate analysis of variance (MANOVA) was used to compare the essay scores of the two groups. The statistical analysis was carried out using the Statistical Package for Social Sciences (SPSS-X) software using the MANOVA procedure for repeated measures experimental design. For each group, the scores on the essays represented the dependent variable, with the essay number a repeated factor or a within-subjects factor. The group membership of control or experimental groups represented the between-subjects factor. The MANOVA procedure generated a set of transformed variables to test the between-subjects and within-subject effects. The transformation used here was the contrast-difference transformation, also known as the reverse Helmert measure, and was set at the .05 confidence level. Two contrast-difference comparisons were made, comparison between groups and the comparison between means with each group.

Comparison between the Experimental and Control Groups

The overall difference between groups was examined using a two-way MANOVA, with essay number (1, 2, 3, 4) as the within-subjects factor, and using membership of groups as the between-subjects factor. This enabled any differences in the pattern of changes between essays for each group to be examined as an interaction effect. A two-way MANOVA for the significance of the differences between the experimental group essays and the control group essays is shown in Table 7.7. The table indicates there is a significant difference ($p < .01$) between the trends of the experimental and control groups which are displayed in Figure 7.4. Table 7.7 shows a highly significant essay effect indicating that there are differences in means of the four essays. Therefore it is reasonable to test further for significant difference between the different essays.

Table 7.7

Results of the Two-way Repeated Measures Analysis of Variance between Experimental and Control Groups

Source of variation	Multivariate analysis of variance			
	SS	df	F	p
Essay	407.54	3	45.10	.000
Groups by essay	20.16	3	2.23	.084
Within cells	1355.37	450		

Comparisons between Essays in the Experimental and Control Groups

For each group separately, the MANOVA procedure was used to produce the contrast statistics between various combinations of the essay means. Table 7.8 reports the results of these one way repeated measures analyses of variance, and shows that for both groups, there are significant differences between the means of the essays.

Table 7.8

Results of the One-way Repeated Measures Analysis of Variance between Essays of Experimental and Control Groups

Source of variation	Experimental Group				Control Group			
	SS	df	F	p	SS	df	F	p
Essays	433.56	3	45.97	.000	109.32	3	13.34	.000
Within cells	961.94	306			393.43	144		

The contrast analysis was applied to the four means of each group as follows: essay 1 versus essay 2; essays 1 and 2 versus essay 3; essays 1 and 2 versus essay 4; essays 1 and 2 versus essays 3 and 4; and finally essay 3 versus essay 4. The purpose of this analysis was to determine the statistical significance of the changes in essay scores. The results are depicted in Table 7.9.

For the experimental group the results show that the change between essay 1 and essay 2 was not significant. However, significant change occurred from these initial essays to essay 3, and again to essay 4. The changes demonstrate improvement, as shown in Figure 7.4.

For the control group, the changes between the first three essays are significant and then the improvement to essay 4 is not so marked. This suggests that under current practices for teaching the writing of essays, as used with the control group, students improve steadily over about three essays, approximately one and a half semesters, and then reach a plateau of performance.

On the other hand, in the experimental group, students under SLDP were still improving significantly at the fourth essay, that is till late in the second semester. Also, as illustrated in the graph of Figure 7.4, it is clear that the overall improvement has been greater in the experimental group.

Table 7.9

Results of Contrasts between the Essay Mean Scores of the Experimental and Control Groups

Comparison	Experimental group		Control group	
	F	p	F	p
essay 1 versus 2	.59	.443	1.38	.245
essays 1 & 2 versus 3	46.30	.000**	22.45	.000**
essays 1 & 2 versus 4	104.85	.000**	37.13	.000**
essays 1 & 2 versus 3 & 4	111.53	.000**	45.16	.000**
essay 3 versus 4	12.22	.001*	1.24	2.72

* p < .01, ** p < .001

Further analyses were conducted to investigate whether there were differences in improvement trends, first according to the students' gender, and second according to the students' ability, independently measured as their writing-in-science potential (WISP).

Analysis of Results according to Gender

The results according to gender are shown in Table 7.10. This analysis reveals the same trends as shown in the overall results. There is an improvement trend for males and females in both experimental and control groups. However, the improvement is greater for both males and the females in the experimental group compared with the improvement in the control group.

The results further show there is some difference between males and females initially in both groups, but they approximately achieve the same mean scores at the end of the trial. This means that the males have shown a greater improvement than the females in both experimental and control groups, and may be a result of the later maturing of males towards their potential. However, the important result for this study is that both males and females in the experimental group showed a greater improvement than those in the control group.

The improvement trends are illustrated in Figures 7.4 and 7.5. Tests of statistical significance were not attempted because of the small number of students in the control sub-groups of males and females. The trends, however, are consistent with the overall results and support the claim of the overall effectiveness of SLDP.

Table 7.10

Comparison of Essay Mean Scores of Males and Females in Experimental and Control Groups

	Experimental group		Control group	
	Males n = 68 $\bar{x}$ (SD)	Females n = 35 $\bar{x}$ (SD)	Males n = 33 $\bar{x}$ (SD)	Females n = 16 $\bar{x}$ (SD)
Essay 1	2.84 (2.05)	3.09 (2.12)	3.15 (1.95)	3.81 (1.91)
Essay 2	2.36 (1.70)	3.46 (1.90)	3.45 (2.09)	4.56 (3.01)
Essay 3	4.00 (1.96)	4.94 (2.10)	4.63 (2.01)	5.31 (1.92)
Essay 4	5.40 (1.85)	5.03 (1.96)	5.21 (2.16)	5.19 (2.37)

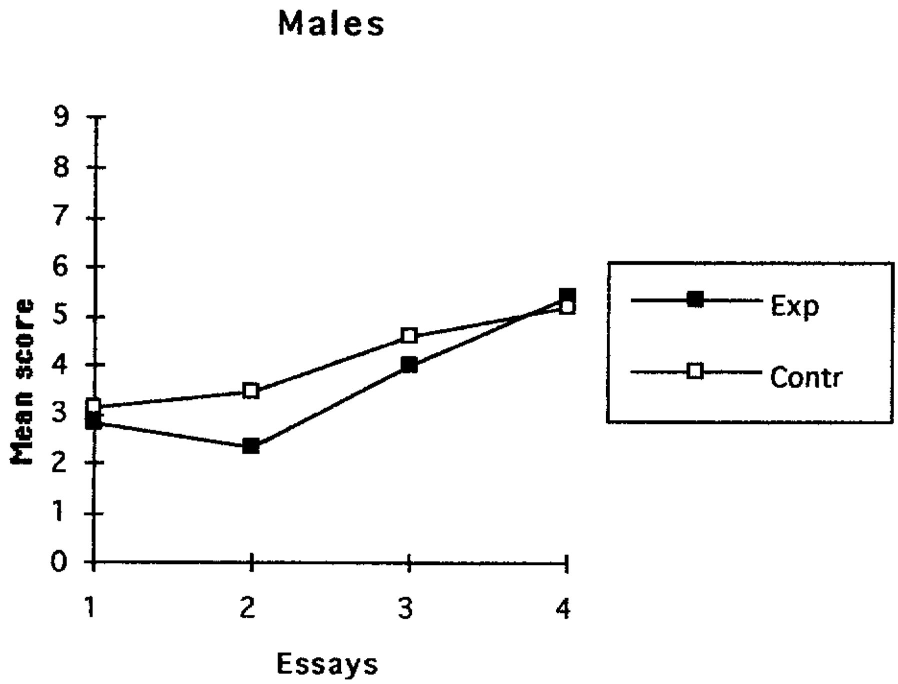

Figure 7.5. Essay mean scores of males in experimental and control groups.

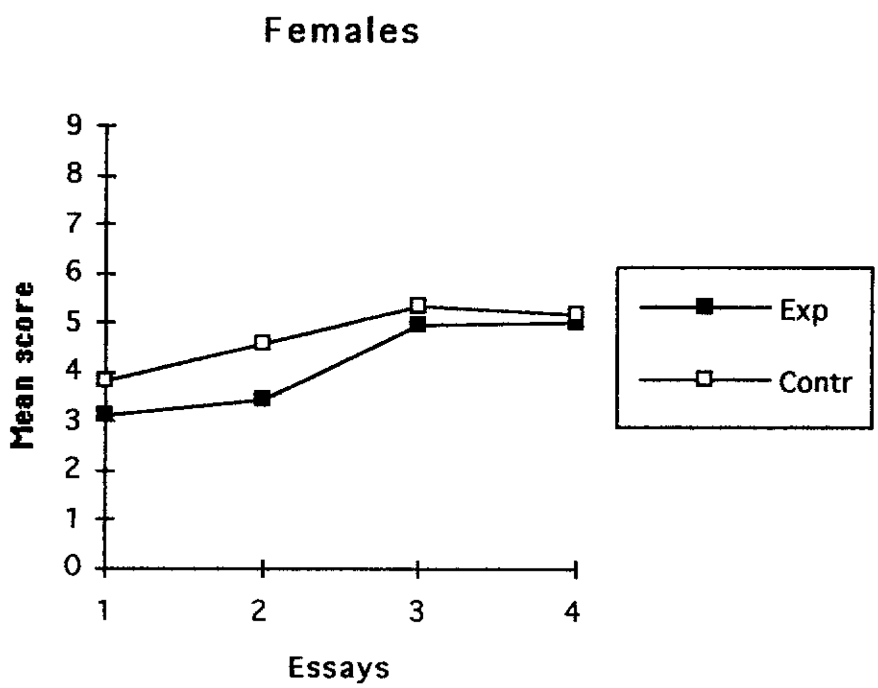

Figure 7.6. Comparison of essay mean scores of females in experimental and control groups.

Analysis of Results according to WISP Band

The students were divided into seven bands according to independent criteria for establishing their Writing In Science Potential (WISP), as described previously. The numbers of students together with the means of the four essays within each band, are shown in Table 7.11. The improvement of experimental and control groups within each band was compared and trends across the essays plotted in Figure 7.7. The numbers within bands were too small for meaningful tests of significance, such as MANOVA, to be employed, but the differences between experimental and control groups within bands are visually displayed in Figure 7.7. The bands were not combined because of the difference in criteria in establishing the bands in the first place. For example band 3 (the good in physics weak in English) could not be combined with band 4 (the good in English and weak in physics) without losing the purpose of the bands.

Experimental group. The effectiveness of SLDP is apparent in the improvement in all bands of WISP. The improvement seemed to be greater in the middle and lower bands than in the higher bands, but even here the improvement was greater than in the corresponding bands of the control group. It seems clear that in each case for the experimental group, there was an increased improvement after essay 2.

Control group. The general improvement in the control groups was greater in the middle bands than in either the higher or lower bands. It seemed that in the control group, students in the higher bands reached a plateau while students in the lower bands did not respond to normal classroom practices. This latter observation was supported by the higher sample mortality (students not completing or handing in assignments) in the sixth and seventh bands than in the other bands.

Table 7.11

Essay Mean Scores of Experimental and Control Students in each Band of WISP

Band of	Experimental group			Control group		
WISP	Number of students	Essay	$\bar{x}$	Number of students	Essay	$\bar{x}$
1	16	1	3.87	11	1	4.54
		2	3.68		2	6.27
		3	5.37		3	6.40
		4	5.87		4	6.54
2	14	1	3.64	13	1	3.00
		2	3.71		2	4.52
		3	5.42		3	4.38
		4	5.50		4	5.31
3	3	1	4.00	0		
		2	3.33			
		3	5.00			
		4	6.33			
4	18	1	2.94	4	1	4.25
		2	2.56		2	4.00
		3	4.11		3	4.75
		4	4.83		4	6.25
5	25	1	2.68	11	1	3.27
		2	2.40		2	3.64
		3	4.23		3	5.09
		4	5.42		4	5.18
6	17	1	2.47	7	1	2.07
		2	2.23		2	2.00
		3	3.29		3	3.85
		4	5.17		4	3.00
7	10	1	1.60	3	1	1.00
		2	1.60		2	0.33
		3	3.10		3	1.33
		4	3.29		4	2.33

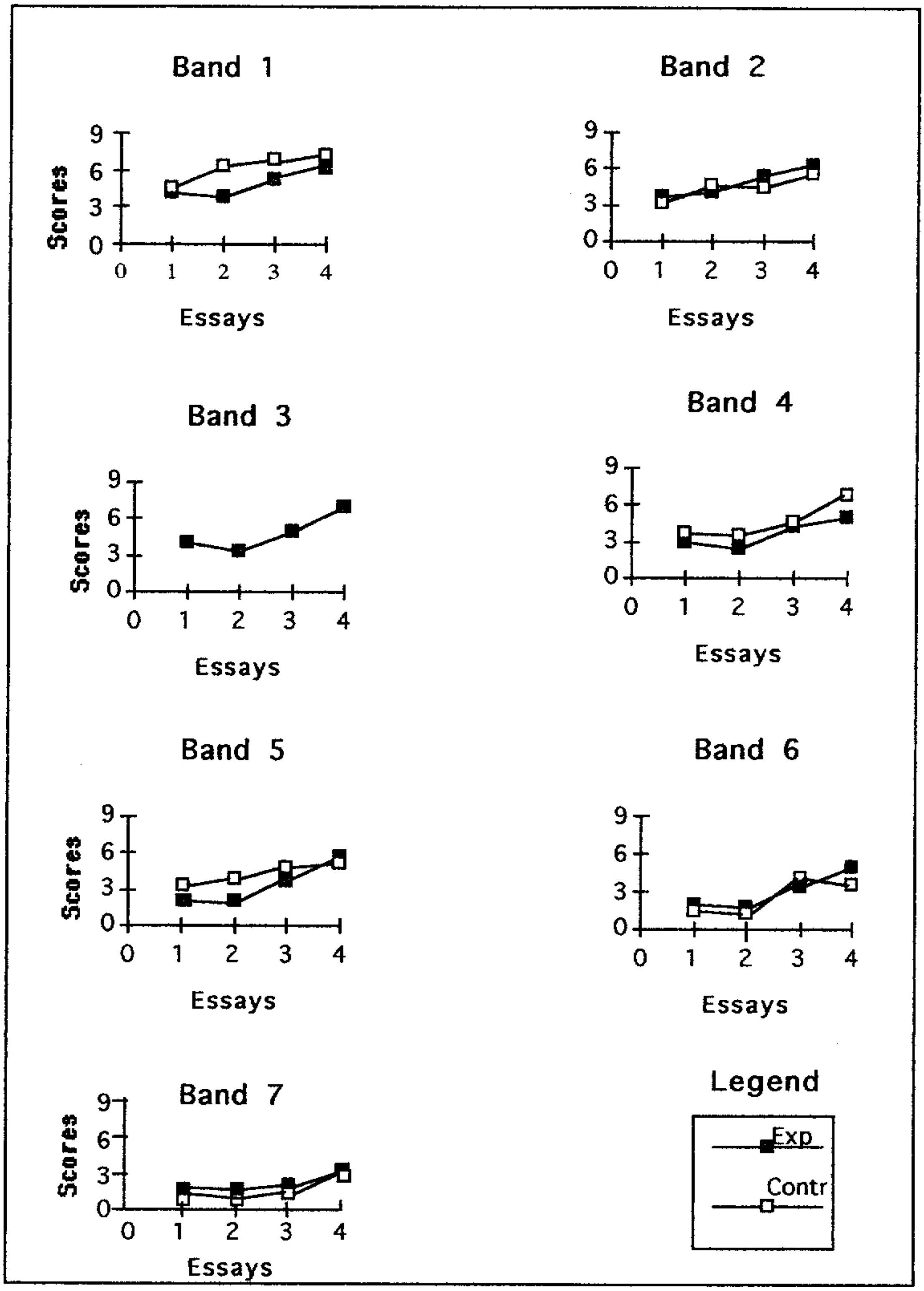

Figure 7.7. The comparison of trends in essay mean scores of experimental and control groups within bands of WISP.

Qualitative Results

The qualitative results were collected from a post-SLDP student questionnaire and a post-SLDP teacher questionnaire, observations of classroom dialogue and observation of problems encountered during classroom sessions. The qualitative analysis led to findings about other aspects of the trial.

Post-SLDP Student Responses

The post-SLDP questionnaire (contained in Appendix 7.3a) was given to all experimental and control group students. The questions were about student attitude to writing in physics and the responses of the two groups were then compared.

The first question asked: *Do you find it easier to write essays in physics, English, neither subject, or the same?* Of the experimental group, 23% (n = 81) chose physics compared with 10% of the control group (n = 40). This represents a significant difference between the groups which may be attributable to the experience with SLDP. The reasons (required by the second question) for choosing English were similar in both experimental and control groups, whereas some of the reasons for choosing physics as preferred writing task seemed to result from the components of SLDP. For example some statements were: *physics requires explanation, physics has ideas from concepts, physics uses related facts, the facts have to be related.* The reasons for choosing English were similar to those expressed in the first extended study and the pilot study: *English is creative, expression of personal feelings, it is more imaginative, less structured.*

In response to the third question about the differences in writing style (*What do you think are the differences between the style of writing between physics and English?*), the experimental students were able to describe more differences between physics and English than were the control students. These perceptions may also be attributable to the experience with SLDP.

The fourth question concerned the assistance that reading gave to either physics or English. Approximately 43% of the experimental group expressed the view that reading helped physics compared with 22% of the control group with that opinion.

The fifth question concerned the enjoyment of writing essays in physics this year. Answers were given on a five point scale: none, little, some, much, very much. The mean of the experimental group was 3.00 corresponding to 'some' enjoyment. The mean of the control group was 2.71 which is less than 'some' enjoyment. This seemed to indicate that those using SLDP found writing in science had been more enjoyable than those who did not use SLDP.

The student questionnaire responses confirmed the quantitative data that SLDP was effective in both increasing the rate of improvement and also increasing the students' perception that writing in physics was easier, more relevant to reading and more enjoyable than would be the case without SLDP.

Post-SLDP Teacher Responses

The teacher questionnaire (see Appendix 7.3b) was the same as that given in the first extended study and hence it was given to the new teachers, Phons, Liam, Guy and Vic, and also to Fred, a third time user, for comparison. Results were much the same as those of the first extended study, endorsing the various aspects of the program. In conversation with the teachers during the second extended study, the researcher was able to ascertain the need for computer assistance in some of the mechanics of writing: spelling, punctuation, sentence construction and paragraph writing. This led to a further development in the HCP modules, described later in the chapter.

Some of the new comments from the new trialling teachers were as follows. Rating implies a scale of effectiveness from none to very high. Rating of concept mapping:

Liam: *high effectiveness;*

Fred: *very high effectiveness;*

Guy: *high effectiveness;*

Vic: *High effectiveness.*

Rating of contextual readings:

Liam: *some assistance;*

Fred: *high effectiveness; would be very much assistance if they were detailed---use scrolling;*

Guy: *Some assistance;*

Vic: *Some effectiveness.*

Rating of writing models:

Liam: *high effectiveness;*

Fred: *very high effectiveness;*

Guy: *unsure;*

Vic: *some effectiveness.*

Rating of elementary sentence construction:

Liam: *some effectiveness;*

Fred: *very high effectiveness;*

Guy: *my students didn't really need this;*

Vic: *some effectiveness.*

Rating of paragraph writing:

Liam: *high effectiveness;*

Fred: *very high effectiveness;*

Guy: *some effectiveness;*

Vic: *some effectiveness.*

Rating of genre and language register of science;

Liam: *high effectiveness;*

Fred: *some assistance---still rushed---students didn't expect this in physics lessons;*

Guy: *some assistance;*

Vic: *high effectiveness.*

Improvements suggested:

Liam: *more contextual readings;*

Fred: *coloured HyperCard, quicktime video, animation, experimental simulations;*

Guy: *Some concepts used in Year 11 electricity would not normally be covered;*

Vic: *Paragraph writing lesson could be simplified---too theoretical/abstract.*

Enjoyment by students:

Liam: *some students found the concept maps hard. Some students (weaker students) did show an improvement in their essay writing skills;*

Fred: *Yes, use of computers---satisfaction of writing a good essay;*

Guy: *Yes, not a chalk/talk lesson;*

Vic: U*sing the computer---HyperCard. And concept mapping.*

Would the teacher use it again?

Liam: *Yes;*

Fred: *Yes, yes!*

Guy: *At a different point in the topic.*

Vic: *Yes---the shorter form.*

Other comments:

Liam: *It should help them to organise their thoughts and give them extra practice at writing. Also explains the mechanics of writing essays.*

Fred: *I have seen the usefulness of the program and will continue to use it in Year 11 and Year 12. Some students still write essays first---then construct concept map from it, particularly ESL.*

Phons: *I am sorry to be a slouch re return of these essays. No excuses! I am still short of M's and J's. Students had exams last week and work experience this week. I've even rung home to remind them! I was disappointed in their efforts. They had four lessons on computer to prepare concept maps but there was considerable 'jumble' over using them and getting the system to run properly.*

Guy: *Unfortunately, it doesn't fit into teaching time, even though students are learning about concepts at the time. This fear would be reduced when Stage 2 course content made more realistic.*

Vic: *I think it would have been better to have partly covered the topic before starting SLDP.*

The conclusion that can be drawn, from these responses is that familiarity and experience with SLDP, as was the case for Fred, enables the teacher to use SLDP more effectively. Also teachers such as Fred were able to see its potential for further development and adaptation to their own teaching needs.

Duologue Strategies

During the use of the HCP modules, the participating teacher moved from student to student to engage in one-to-one dialogue. The amount of dialogue about the meaning of physics concepts, the structure of concept maps, the use of relational statements was considerable. The analysis of this dialogue was carried out by tape recording a number of typical lessons: Fred's lessons L-10, and L-11 with students working with the HCP module 'Light'; Dan's lesson L-11 with students working with the HCP module 'Sound'; Liam's lesson L-11 with students working with HCP module 'Dynamics'; and a video tape of Sandra's lesson L-6 with students on paragraph writing. The transcript of one such 40-minute lesson is contained in Appendix 7.4a and for purposes of comparison, the transcript of a regular classroom lesson is contained in Appendix 7.4b.

An analysis of the transcripts was carried out using a reinterpreted version of Hymes's model (Hymes, 1968) of the communicative economy, proposed by Malcolm (1982) and used for analysis of classroom dialogue. The model is a combination of Halliday's three macro-functions, ideational, interpersonal and textual functions in dialogue (Halliday, 1975), and Hymes's seven functions of speech, illustrated by the coding assigned to the transcripts in Appendix 7.4a and 7.4b. As explained earlier in Chapter 4, the dialogue strategies were assessed according to the method of Lemke (1990) as the teacher question and answer (TQA) series; the teacher question, elaboration and modification (TQE&M) series; and the joint construction (JC) series. Analysis of the dialogue in classroom discourse and of the dialogue at the computer work stations, enabled the differences to be assessed. The patterns of dialogue in the HCP activities are compared to the patterns of discourse in regular classrooms and are depicted in Table 7.12.

The most obvious effect was the increased proportion of student-initiated questions compared with teacher-initiated questions in the SLDP lessons. The great majority of speech events in the regular classrooms were in the pattern of initiating, responding, evaluating, with the teacher initiating approximately 75% of the interactions. In the lessons using HCP modules, the patterns of speech events were more complex and were largely (at least 75%) initiated by students. The interpersonal functions of the discourse within the dialogue were greatly increased with HCP activities compared with the regular classroom dialogue, in which the ideational function of the dialogue dominated.

Table 7.12
Comparison of Dialogue in Regular Classrooms and with HCP Modules

Functions of dialogue	Student initiated interactions in regular classrooms	Student initiated interactions at computer work stations
Ideational	approximately 10%	approximately 25%
Interpersonal	approximately 25%	approximately 75%
Textual	approximately 10%	approximately 20%

This difference in patterns of dialogue between classroom dialogue and the computer work station duologue indicates the effectiveness in the interpersonal functions of discourse, and to a less extent, the ideational and textual functions as well.

Observation of Problems Encountered

Difficulties with the conventions of English spelling, punctuation and grammar continued to be a problem for some students, particularly for those with non-English speaking background, as reported in the first extended study. The principal limitation of the HyperCard software, was that it offered only very limited text checking facilities. There are simple word processing facilities such as *cut, paste, delete* but no syntactic or semantic guides, such as spelling checkers, grammar checkers and document statistics. To work at a higher level of word processing it was possible for students to transfer the text of their written composition to a *Word* or *Works* computer application to use the comprehensive checkers and document statistics display. An alternative might have been to transfer the written text to a specific grammar program such as *Grammatik Mac™* that offered comprehensive checking. These alternatives to using HyperCard software were probably applicable in ESL classes where time and assistance was available for direct teaching of the English form of style, grammar and spelling. However, the advantages of remaining with HyperCard software in physics classes were first, specific checking could be customised to cater for particular topics in the physics course; second, considerable time could be saved by not having to transfer text into another application; third, a simple program in HyperCard checking could be quicker than the fully comprehensive checkers.

The development of the checking facilities in HyperCard was carried out during the second extended study and partially completed by the conclusion of it but was not trialled in the study itself. However, an account of the development of the checkers is described later in this chapter and the consequent review by teachers provides an estimate of its likely effectiveness. It was anticipated that this facility would enable students to improve their use of language within the accepted conventions of English writing. The checking was to be by prompt only, so that students did not lose control of or responsibility for their own review and editing of text.

Specific Analysis in Terms of Elements of the Definition of Scientific Literacy

The analysis of results to establish the effectiveness of SLDP related to specific elements in the proposed definition of scientific literacy required a search for evidence of: activating the cognitive processes, engaging in the discourse of science, using a form of language register of science, and communicating in the proposed pathways model of writing, for scientific literacy. These were the specific elements for which an analysis of results was done as follows.

Activating the Cognitive Processes

It was argued in Chapter 3 that activating the cognitive processes could be done by using hypertext facilities. The hypertext facilities of the HCP modules enabled the creation of a representational schema in the construction of concept maps with propositional links that established superordinate, subordinate and associative links between concepts. The concept mapping was done through using multiple pathways, which enabled students to use prior knowledge, concept definitions, reading texts, and teacher-student duologue to assist them to create the representative schema.

Evidence for development in concept mapping skills was therefore investigated in the first specific analysis. The aspects of concept mapping analysed were as follows: the number of concepts individually defined and linked to other concepts; the use of an hierarchical structure in which there was a clear gradation of levels from abstract and general concepts to particular examples and applications; linking was used in various ways to show subsumation, integration and differentiation according to the Cornell model of concept maps (Novak & Gowin, 1984). The relational statements were examined for simple connectives and verb phrases and compared with the relational statements that were technical phrase relating to physics laws, equations and explanations.

The third essay written was based on a concept map drawn within a HCP module, and the fourth essay resulted from a concept map in a different HCP module. The mean scores of this second application are comparable to the first, even though done some months later and with much less preparation time, approximately two lessons compared with 12 lessons. In other words the elements of concept mapping were well enough understood to be retained and repeated for different topic.

The results of this investigation were measured with the scoring scheme for concept maps (Cronin, et al., 1982). The results are depicted in Table 7.13. The number of concepts used was approximately 12 (one point for each distinct concept), ranging over three to four levels of complexity (two points for each level), and using at least six different relational statements (one point for simple connectives and two points for technical phrases). The students created concept maps with a structure that could not be copied from any reference source and hence they were idiosyncratic representations of their own cognitive processes in that topic. The results of scoring the features of the concept maps are depicted in Table 7.13.

Table 7.13
The Scores for each Feature of the Concept Maps

Skills of concept mapping	Essay 3 concept map mean $\bar{x}$ SD)	Essay 4 concept map mean $\bar{x}$ (SD)
Number of concepts	12.06 (4.05)	12.41 (2.23)
Hierarchical structure	6.67 (3.76)	7.29 (2.04)
Linking of concepts	12.51 (3.20)	11.84 (3.53)
Branching points	5.52 (2.49)	5.03 (2.78)
Relational statements	6.78 (3.60)	6.16 (3.53)
TOTAL	43.54	42.73

Examination of concept maps indicated that some were developed from general to specific topics in a top-down fashion. Others were developed from specific to general concepts and the text processing strategies followed a similar pattern. Other concept maps showed less of a hierarchical structure and could be read in a lateral fashion. the text processing strategies identified were:

* hierarchical top-to-bottom (HTB) in about 40% of cases;
* hierarchical bottom-to-top (HBT) in about 10% of cases;
* lateral related branches (LRB) in about 20% of cases;
* lateral unrelated branches (LUB) in about 20% of cases;
* undifferentiated sequence (US) in about 10% of cases.

Comparison of the use of such text processing strategies between experimental and control groups is reported later.

Further analysis of the concept map scores was done according to the placement of students in the bands of WISP to see if there was any significant variation of concept map scores with bands of WISP. The results indicated no significant difference in means between bands ($p > .2$) in the scores of the seven bands of WISP. This might be explained by the fact that concept mapping eliminates or reduces written language constraints, allowing students, especially those with language difficulties, to build their personal cognitive processes around the topic. An example to illustrate this, is a concept map done by a student with poor language skills as contained in Appendix 7.5. In Chapter 3, the Classicist notion of language of thought being independent of the language of communication was explored and this may offer an explanation for the success of concept mapping independent of language skills. This supports concept mapping as an agent for activating the cognitive processes.

During the concept mapping lessons, teachers were active in duologue with students about their concept maps. The analysis of pathways discussed in a later section indicated that student-teacher dialogue was significant during this stage. The explanation of learning mechanisms according to either Classicist or Connectionist theories is supported by the idiosyncratic nature and the durability of concept mapping techniques.

Engaging in the Discourse of Science

The SLDP allowed for the development of various genres of writing in science, but the focus in this research was on the explanation genre. The most applicable genre for engagement in the discourse of science was the discursive argument genre, in which relativist positions in science could be proposed for students who would then examine them critically. This was beyond the scope of this research, but SLDP presents the potential to teachers for further development and use of this genre as described in Chapter 3.

The SLDP therefore as used in this research provided limited examples of engaging in the discourse of science through the discursive argument genre as shown in Appendix 6.3e, but it has provided a foundation from which such development could take place.

Using the Language Register of Science

The language register of science was described in Chapter 3 as being sociolinguistically determined, and made accessible by using the norm-violations techniques proposed by Lemke (1990). This implied the capacity to use informal language in scientific dialogue as well as the more formal aspects of the use of a specialised vocabulary, use of logical connectives, use of quantitative expressions, and use of illustrations such as graphs, diagrams and tables. A post-SLDP analysis was conducted to detect observable differences between the experimental and control groups in these aspects of the language register of science.

Essays. A representative sample ranging over the seven bands of WISP was analysed. The sample consisted of 114 third and fourth essays from 30 students in the experimental group and from 27 students in the control group. The frequency of use of specialised vocabulary, logical connectives, quantitative expressions and illustrations was counted for both the experimental and control groups. The mean number of each aspect for each group and the difference in means were calculated. A t-test for significance in difference of means between the experimental and control groups was also calculated. The results are shown in Table 7.14.

These results indicate that the experimental group used specialised vocabulary and sentence connectives significantly more than the control group in the third and fourth essays. The use of quantitative expressions was not significantly different, whereas the use of diagrams, graphs and tables was significantly less. This may be explained by the difficulty of using graphics in the HCP modules. Provision was made for students to create space for the manual addition of diagrams, graphs and tables after printing, but it seems that this process was not readily performed by the experimental group students.

Table 7.14
Comparison of Scores for Each Feature of the Language Register of Science

Language register of science	Experimental group n = 60 $\bar{x}$ (SD)	Control group n = 54 $\bar{x}$ (SD)	Difference in means	Significance of difference	
				df	t-value
Specialised vocabulary	9.76 (4.31)	6.93 (3.51)	2.83	112	3.91*
Logical connectives	7.03 (3.09)	6.05 (3.01)	0.98	115	1.74*
Quantitative expressions	1.32 (1.99)	1.23 (1.20)	0.09	98	.25
Diagrams, graphs, tables	0.22 (0.73)	0.98 (1.84)	-0.76	72	-2.9*

* $p < .05$

Class dialogue and computer room duologue. Further data in the use of the language register of science were gathered from the transcripts of tape recordings of lessons as part of the method for examining the effectiveness of SLDP. A comparison was made between the transcripts of the dialogue in a regular classroom lesson and the transcripts of the duologue in the computer room with HCP activities. Although the use of these features was somewhat topic dependent, it was possible to compare the overall patterns. The transcripts of regular classroom dialogue were analysed by using the criteria of Malcolm (1986) for categorising language functions as ideational, interpersonal and textual. Also, student-teacher dialogue was analysed according to the strategies of Lemke (1990), enabling the differences between dialogue in classroom and at computer work stations to be assessed. The strategies are teacher question and answer series (TQA), the teacher question elaboration and modification series (TQE&M), and joint construction (JC).

Perusal of typical transcripts for classroom dialogue and for computer room dialogue in Appendix 7.4a and 7.4b respectively, indicates there is a greater participation in the ideational language functions and the interpersonal language functions by students when using the HCP modules as part of SLDP than in conventional classrooms. The frequency of student-initiated dialogue in the computer room was approximately double that in the classroom as seen in Table 7.15. This doubling effect is probably not attributable to using the HCP module itself, but to the use of computers and would probably apply to other forms of computer-assisted learning packages. However, this result shows that the HCP model for computer-assisted writing also encourages students to use a form of the language register of science more frequently than in a classroom setting.

Table 7.15

Comparison of the Student and Teacher Frequency of Using the Language Register of Science

Language register of science	Regular classroom lesson (n = 6)		Computer room lesson with HCP modules (n = 4)	
The ideational language function	Dialogue initiated by teacher $\bar{x}$ (SD)	Dialogue initiated by student $\bar{x}$ (SD)	Dialogue initiated by teacher $\bar{x}$ (SD)	Dialogue initiated by student $\bar{x}$ (SD)
Using scientific concepts	9.4 (3.4)	2.4 (0.9)	24.0 (8.0)	24.5 (3.5)
Using relational statements	6.8(4.5)	4.0 (2.4)	15.5 (4.9)	10.0 (1.0)
Using applied examples	3.0 (1.9)	2.0 (2.3)	2.0 (1.0)	1.0 (-)
Ratio of student initiated to teacher initiated dialogue	0.43		0.85	

The frequency of using strategies for setting thematic patterns was different between the two settings. The TQA series was most common in the classroom dialogue, while the JC series was most common in the computer room as can be seen from Table 7.16. The increased JC strategies with HCP modules gave students more practice with the language register of science.

Table 7.16

Comparison of Strategies for Setting Thematic Patterns

Setting thematic patterns	Classroom dialogue (n = 6 lessons) $\bar{x}$ (SD)	Computer room dialogue (n = 4 lessons) $\bar{x}$ (SD)
TQA	4.8 (3.8)	2.8 (0.9)
TQE&M	3.4 (2.1)	3.0 (1.4)
JC	1.2 (1.1)	8.5 (2.1)

Using the HCP Model of Writing

Data on students' use of navigational pathways in the proposed writing model were obtained from the diagrams of pathways that students from the experimental group (103 students) recorded during the activity with HCP modules for the fourth essay. The number of pathways diagrams collected from the experimental group was 86, the other 17 did not pass up a diagram. The pathways chosen by the students during the construction of concept maps and essays were analysed. The number of a pathways was counted and a pattern of most frequently used pathways emerged as illustrated in Figure 7.8. The mean number of pathways used is shown in the Table 7.17.

The facility to generate, plan and organise the structure of concepts through computer-assisted concept mapping was the central feature of this HyperCard Pathways model of scientific writing. The essay concept map was chosen most frequently in the back and forth pathways chosen by students in the composition of concept map and essay. These pathways are not normally available within writing models such as those of Flower and Hayes (1980), Bereiter and Scardamalia (1987) and other models described in Chapter 3. It can be claimed that the generating, planning and organising of concepts for writing was made possible for students through the HyperCard Pathways model of writing.

Table 7.17

Pattern of Choice of Pathways during the Composition of the Fourth Essay

Pathways			Frequency of use
Essay concept map	to	dialogue	2.49
Essay concept map	to	writing/typing	2.30
Essay concept map	to	definitions	2.30
Essay concept map	to	reading texts	1.82
Dialogue	to	writing/typing	1.60
Reading	to	definitions	1.37
Writing/typing	to	writing models	1.31
Reading texts	to	writing models	1.29
Essay concept map	to	writing models	1.29
Definitions	to	writing/typing	1.27
Other pathways			1.00

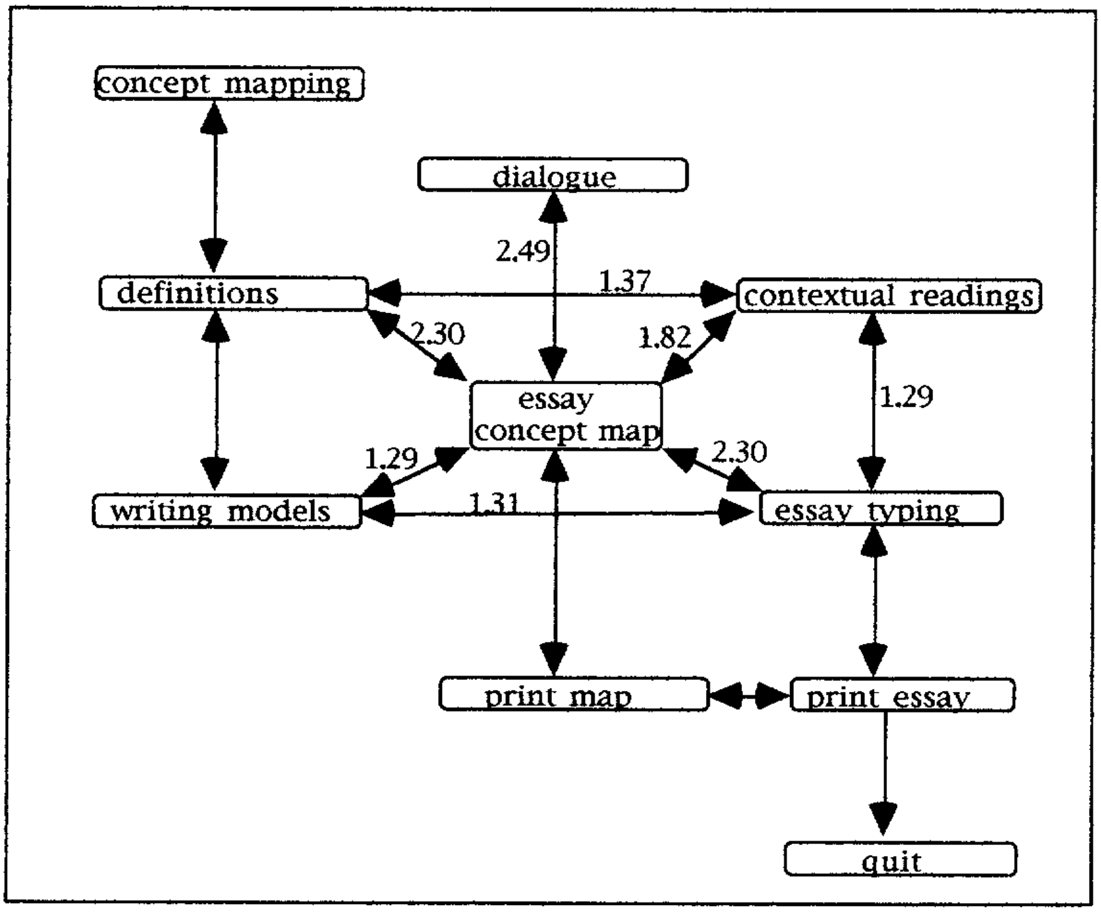

Figure 7.8. Frequency of navigational pathways chosen by students.

Correlation of Pathways with Essay Score

An investigation for correlation between the number of navigation pathways used and the score obtained in the fourth essay was undertaken. The result is shown in Table 7.18. There is an apparent correlation between increasing number of pathways used and increasing essay scores with the exception of the highest scoring students, those with A, A+ and A- grades. It may be explained that the higher scoring students did not need to use pathways as frequently in the composition of their essays, whereas low and middle scoring students used pathways in proportion to their essay grades and the use of pathways may have been a factor in gaining higher scores.

Table 7.18
Comparison of Essays Scores and the Frequency of Navigation Pathways Used

Grades of fourth essay	Corresponding score	Number of students	Number of pathways used. $\bar{x}$ (SD)
Grades C-, C, C+	1, 2, 3	12	7.83 (4.64)
Grade B-	4	3	9.33 (4.16)
Grade B	5	39	9.61 (3.78)
Grade B+	6	21	12.47 (4.09)
Grades A-, A, A+	7, 8, 9	11	9.45 (3.88)

Comparison of Text Processing Strategies

An examination of third and fourth essays from the sample of experimental and control groups, 60 essays and 54 essays respectively, indicated that text processing strategies described earlier were clearly identified in essays written from concept maps (the experimental group) rather than in those without concept maps (the control group). It was possible to identify 39 essays (67%) written in HTB, HBT and LRB strategies compared with 29 essays (51%) from the control group. This is an indication of the value of using concept maps to enhance coherence in proposition-based writing strategies.

Post-Study Developments

Design of the Three Text Checkers

To meet the problems observed during the study that some students had with the conventions of English spelling, punctuation and grammar, three checkers were designed that would meet a few basic problems in each area. The design was *scripted* into the HCP modules and described in the Supplement to the Teacher's Manual to enable teachers to access the checkers and adapt them to their own needs.

Spelling Checker

An effective spelling checker required that the *spelling checker* be placed within an easily accessed screen display for selection by the user. This was done in such a way that the *checker* selected each word (greater than five characters) and checked for discrepancies from the reference word list which was specially created for a each topic.

Three *pop-up windows* were created: one to question whether a selected word was to be replaced; a second window offered a list of words similar to the incorrect one so that clicking on the selected word corrected the one in the first window; a third window provided the choice for not changing the spelling of the selected word with a "Don't change" option. The pop-up windows are illustrated in Figure 7.9.

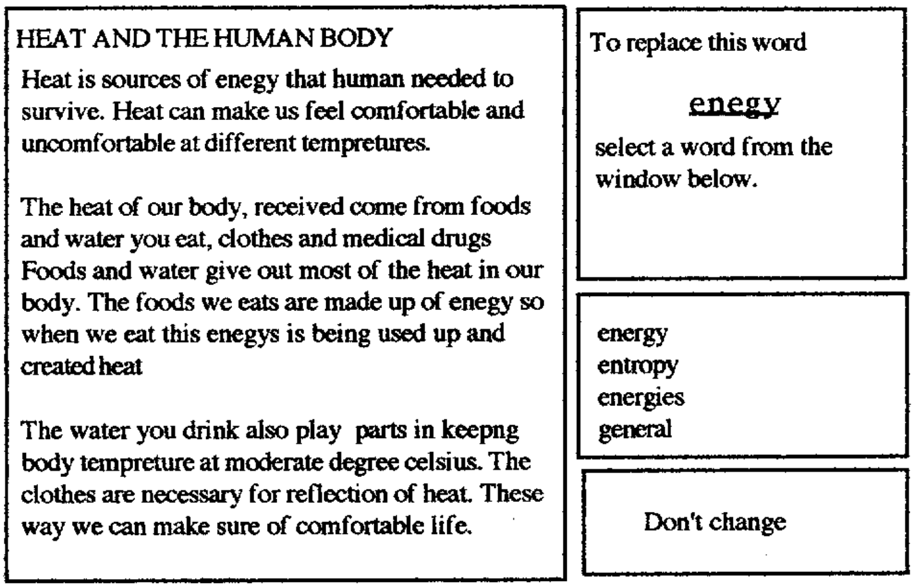

Figure 7.9. The three 'pop-up' windows of the Spelling Checker.

A supplement to the Teacher's Manual (contained in Appendix 7.2) contains directions for teachers to add, delete and edit physics words in the word list for the particular topic. For example, a word list for the 'heat' topic is: capacity, Celsius, condensation, conduction, convection, degrees, energy, enthalpy, entropy, evaporation, hyperthermia, hypothermia, joules, metabolism perspiration, perspiring, radiation, reflection, specific heat, temperature, thermal thermometer, thermostat. In this way teachers can build up word lists of the commonly misspelled physics words in each topic.

Grammar Checker

The *grammar checker* was placed within an easily accessed screen display for selection by the user. The *checker* selected each sentence in order, and presented the user with certain grammatical choices, as described in the following paragraphs.

Punctuation. At each sentence the checker detected if a capital letter was not used at the start of a sentence. A pop-up window then asked if a capital letter was required, followed similarly by a "Don't change" window. It detected whether there was a space after punctuation such as a full stop or comma, also a line space at the end of each paragraph. A pop-up window then asked if a space was required, followed similarly by a "Don't change" window. The *checker* detected "its" and "it's" and asked if a change was required, providing the other alternative.

Singular/plural. When the Grammar Checker came to the word "these" it checked for plural of the next word and asks if "s" was required at the end of that word if not already there. When it came to the word "this" it checked for the singular of next word and asks if "s" was to be deleted if present. If required, every word ending in "s" can be detected and asked for singular or plural, if desired by the teacher.

Connectives. The words "and" and "but" were detected if they were used at the beginning of a sentence. The *checker* asked if the user wanted to change this connective to an alternative.

Other grammar checks required by the teacher such as participles, pronouns, definite and indefinite articles could be scripted following the directions in the Teacher's Manual Supplement (contained in Appendix 7.2).

Document Statistics Checker

Counters. the Count Checker was placed within as easily accessed screen display and for selection by the user. The *checker* compiled statistics such as count of words, count of words greater than six letters, count of sentences, count of paragraphs, and count of sentences greater than 20 words. It supplied these data in a pop-up window.

Ratios. Formulas using ratios of the above counts were devised to give instant feed-back to students. For example, the ratio of six or more letter words to the number of words used was calculated; an index of words to sentence ratio, comparing it with the advised 17 words per sentence, was calculated. A formula was devised to produce a score out of 10 for some of the above conventions of written text. It was thought that the use of such formulas might encourage students to edit, redraft and build their essays towards better quality writing.

It was anticipated that these text checkers would assist students who experienced difficulties with the conventions of the English language, such as the students from NESB. The scripts of the checkers were also made available in the Teacher's Manual Supplement to enable teachers to design their own text checking facilities. Text checking was regarded in this research as being a minor skill compared with the skills of creating, structuring and connecting of text as has been described with the techniques of SLDP. Nevertheless, three teachers who provided an evaluation of these facilities text checking saw them as valuable to students in the final stage of essay composition.

Evaluation of Text Checking Facilities

Three teachers, Fred, Sandra, and Ted provided an evaluation of the text checkers. Their comments were made in response to the questionnaire contained in Appendix 7.6 administered after the conclusion of the second extended study. The teachers reported favourably on three aspects of the spelling checker: its user-friendliness, the range of students it helps, and the adaptability for suiting their own needs. To the question concerning the grammar checker, the same three questions were asked, again with favourable comments. However, one comment is worth reporting:

> *Again it is very user-friendly. However, there would be some students who would still not know which word to use, the existing one or the one provided by the checker. For example, "there" and "their"—there would be some ESL students that would not be familiar with the difference. If a meaning could be provided, this would be useful.*

As to the value of the counter, favourable comment was again made, one comment being:

> *This will help all students as again it would encourage students to use longer words and write the correct amount for WBLA requirements.*

When asked for suggestion about alterations and improvements, the following responses were made:

> Comment. *The text checking facilities do complement the whole SLDP program. Finally there is a (this) program available to NESB students that challenges their drafting and editing skills. The checkers provide opportunities for NESB students to extend their literacy skills in the context of science. It also encourages science teachers to make their teaching more inclusive. Whether they like it or not, they will need to teach punctuation, correct usage of word forms etc! This way NESB students can gain access to the literacy skills valued in our society.*
>
> Comment. *The Teacher's Manual could include sections of instructions/ explanations regarding: punctuation; use of nominalisation; use of*

passive voice; correct usage of verb endings; use of linking words; use of articles. Other science teachers do not know how to explain the above to their students.

Comment. *Yes, the checkers do complement the SLDP program. The 'marker' is also of great use for students during the writing of an essay. The fact that the essay would be typed would also be of use---easier to read.*

Design of a HCP Biology Topic

The design of a HCP module in biology meant the adaptation of one of the other modules into this new topic. It was developed at the request of a teacher. Its development proved that the SLDP strategies can be extended into other science subjects.

Vertebrates

This module was developed for a general pre-year 11 topic, vertebrates. The definitions, concepts, contextual readings, models of writing pieces and concept mapping facilities were all developed for the topic. The contextual readings were extracts from the Visual Dictionary of Animals, (Reader's Digest, 1992) and essay models from Emu Farm, (Maguire 1993) and Darwin's theory of evolution from Asimov's New Guide to Science, Asimov, (1984). The reference list is contained in Appendix 7.7 as well as in the HCP module with acknowledgment for permission to use these extracts.

Concepts: vertebrates, mammals, monotremes, marsupial, body temperature, amphibians, reproduction, habitat, metamorphosis, dolphin, adaptation. Definitions were made available to the students by means of *pop-up windows* which could be accessed from any part of the module.

Relational statements: has, used, is a an example of, contains, belongs to, is measured by, is the property of, causes, for, and, nor, because, or, yet, so, by evolution, by taxonomies, by meiosis, by mitosis.

Contextual readings: animal bodies; animal heads;cartilaginous fish and bony fish; amphibians; lizards and snakes; crocodiles and turtles; birds; primates; marsupials and pouched monotremes.

The writing models: a narrative account of the work on an emu farm; an explanation of Darwin's theory of evolution.

The HCP vertebrates module contained the concept mapping, writing facilities, assessment scheme and the text checkers. The spelling checker was made to include only the words relevant to this topic. The rather basic grammar checker was left as it was because the module was meant for a pre-year 11 topic. This also could be adapted according to the teachers' needs. The extension of SLDP through the new HCP module in a biology topic indicates that SLDP can be adapted to other sciences apart from physics as with the two chemistry modules in the second extended study.

Chapter Summary

The quantitative and qualitative data collected in the second extended study provided evidence to support the hypothesis that a scientific literacy development plan, the SLDP incorporating a HyperCard Pathways model of writing, was successful in improving writing in the scientific explanation genre. Results also showed that the SLDP addressed specific elements of scientific literacy, such as activating the cognitive processes, using the language register of science, and applying a HyperCard Pathways model of writing in the scientific explanation genre. The SLDP was not able to engage students fully in the discourse of science as defined earlier. The reason was that this engagement required research into student writing in another genre of writing, the discursive argument, which was outside the scope of the pilot and extended studies. The potential of SLDP for adaptation to development of the discursive genre has been made clear.

The second research question about establishing the components of a scientific literacy development plan for Year 11 physics was addressed in the pilot study and refined in the first extended study. These components were organised into a 12 lesson program called SLDP and implemented by participating teachers within their normal course schedules. The SLDP included computer-assisted-learning modules for implementation.

The third research question, concerning the effectiveness of SLDP in producing a general improvement in scientific writing, was addressed in the first extended study and the second extended study. The SOLO taxonomy

(Biggs & Collis, 1982) was adapted to provide a measure for a scientific explanation genre assessment scheme (SEGAS). Seven bands of writing in science potential (WISP) were used to investigate the relevance of SLDP to all physics students. Both quantitative and qualitative findings showed that SLDP did produce a general improvement of scientific writing in the explanation genre within the limits of the experimental design, sample selection and the difficulties of data collection.

The fourth research question, concerning the specific elements of scientific literacy that the SLDP addressed, indicated that SLDP was an effective tool and had potential for further development in the enhancement of scientific literacy of Year 11 physics students. The individual choices of students in completing the SLDP and in composing their essays, indicated that a multiple pathways approach to scientific writing was effective. The incorporation of SLDP techniques into the regular course schedules beyond the trial periods has also been adopted by some teachers.

CHAPTER 8
SUMMARY, IMPLICATIONS AND CONCLUSIONS

Introduction

About the time of the International Literacy Year, 1990, the need for greater attention to literacy objectives across all subject areas within the curriculum was being canvassed. Inquiries such as the Gilding Enquiry, (Gilding, 1989) and the Writing and Reading Assessment Program (WRAP) (Education Department of South Australia, 1992) revealed the need for new teaching strategies to enhance literacy, including scientific literacy, in secondary school students. However, a review of the literature revealed that the term scientific literacy was defined by scholars within their own discourse area, and there was no clear comprehensive definition of the term. The Gilding Enquiry and WRAP themselves indicated a need for better literacy, presumably under a more comprehensive meaning of the term, among senior secondary students in all subjects, including science. A symptom of the problem was the under-performance of physics students in extended writing tasks at the public examinations for tertiary entrance. This and other indicators suggested there was a need for better teaching and learning strategies for scientific literacy at the senior secondary level. This study set out to investigate this need. The first priority was to establish a comprehensive definition of the term scientific literacy.

The diversity of meaning of scientific literacy was identified at the commencement of this research. Previous studies seemed to provide definitions focussed on specific areas of literacy, for example, the level of knowledge and understanding of science, the level of concern expressed about the societal impact of science, or the level of language skills required for communication of science. However, with the need for greater attention to concerns of literacy across all areas of the curriculum, a more comprehensive definition of the term was required.

The purpose of this study was fourfold: to investigate the meaning of scientific literacy and to formulate a comprehensive definition of the term; second, to determine and develop the elements of a scientific literacy development plan for upper secondary science students; next to trial the plan, called SLDP, for its general effectiveness in relation to students' performance in explanation genre writing, and teachers' integration into course schedules; and finally to analyse the plan's specific effectiveness in relation to elements of the definition of scientific literacy.

The design of the study was first to establish a theoretical framework for activities in scientific literacy and then to develop the SLDP in three developmental phases which were trialled in regular classrooms to evaluate the effectiveness of SLDP. The research design centred on four research questions that were addressed throughout the three phases of development and trial. The summary of findings is reported here as the response to the four research questions.

Summary of Findings

The findings are discussed in relation to the four research questions proposed in the introduction to the thesis, Chapter 1, under the purpose of the research.

The First Research Question:
How is scientific literacy to be defined, and what are its elements?

Theories about the cognitive processes relevant to scientific literacy were reviewed. This review revealed that activating cognitive processes, whether they be described according to Connectionist models of cognitive architecture or Classicist models, was central to scientific literacy. This was because the theories provided explanations for mental representation, language of thought, and learning mechanisms, even though there was some debate in the literature about the competing models.

The cognitive processes for scientific literacy are activated within the discourse in science and are communicated in a language register of science, and for Australian students, within the conventions of the English language. The need for this latter aspect was established by the Gilding and WRAP reports as well as the record of Year 12 students' performance in writing tasks at the public examinations. This research revealed that using the English language conventions may be a problem, particularly for the non-English speaking background (NESB) students, but it is necessary for teachers to address the more fundamental activities of scientific literacy in the area of activating cognitive processes and understanding the discourse of science as well as addressing the conventions of English language in an integrated program such as proposed here.

A review of the literature indicated that the meaning of scientific literacy could be categorised into three referent areas: the level of science knowledge and understanding, the level of concern about the impact of science, and the level of language skills used to communicate science. However, the focus and emphasis in each reference served to highlight different meanings for the term scientific literacy, thus a more comprehensive definition was sought.

The review of theories concerning cognitive processes, the discourse of science and the language register of science provided a theoretical framework from which that definition was formulated. The resulting definition was that:

> **Scientific literacy is the human function of activating the cognitive processes in the discourse of science and communicating this discourse in a form of language register of science.**

Various models of cognitive writing were examined and there appeared to be four thought processing units that were used in the production of cognitive writing. These are, first, a high level executive central processor directing the whole operation of concept mapping or writing towards its purpose. The second is a lower level processor of knowledge communicated according to an intuitively learned genre scheme. The third processor, below the intuitive genre scheme, is a content processor for extracting semantic material from long-term memory in verbal and non-verbal propositions. Finally, there is a language processor that invokes explicit language directed towards the purpose of the writing and in keeping with the genre scheme required.

The proposed definition requires that these cognitive processes are activated in the discourse of science and communicated in specific scientific genres. Therefore the definition of scientific literacy was made practicable by devising a new model of scientific writing that utilised computer-assisted design for hypertext transitions during the composition process. The particular computer application employed was the HyperCard for *Macintosh* computers. The scientific writing model is called the HyperCard Pathways model (HCP) and is embedded in a comprehensive classroom application called a Scientific Literacy Development Plan (SLDP).

The purpose of this research was to develop the SLDP in order to improve the scientific literacy of senior secondary students. The essential components of such a plan were then deduced from a number of sources, including a study of the literature, advice from teachers and literacy experts, and surveying students. These essential components were the subject of the second research question.

Second Research Question:
What are the practical components of SLDP for Year 11 physics students? This question implies a further sub-question: How are these components to be developed, refined and integrated into a cohesive plan?

The definition was made operational for Year 11 students by adopting what is called here a HyperCard Pathways (HCP) model of scientific writing. Topic modules were developed for the Year 11 physics curriculum called HCP modules and, later, a limited number of HCP modules in chemistry and biology was added. The HCP model of scientific writing assists students to integrate within the one activity, concept mapping, contextual readings, definition of concepts, and composition of essays. This integration required the development of a number of components.

The components of an adequate scientific literacy development plan (SLDP), were:

* Language acquisition through:
  - elementary sentence construction,
  - paragraph writing,
  - writing of the various scientific genres,
  - using the language register of science;
* concept mapping using:
  - definitions of concepts,
  - hierarchical levels,
  - links, cross links and branching,
  - relational statements,
  - simple connectives and technical propositions;
* duologue strategies and extended writing:

norm-violations,
thematic patterns;

* HCP topic modules consisting of:
  contextual readings,
  writing models and an assessment scheme,
  HyperCard pathways between all components.

The implementation schedule of SLDP consisted of 12 regular lessons with at least six computer-assisted lessons, as depicted in Table 5.8. Although the implementation schedule in this research required 12 contiguous lessons, the components could be used separately throughout a regular course schedule. Also the fact that the SLDP was designed in topic modules made it possible for teachers to use any number of the topics in a regular course schedule.

The SLDP components were developed progressively. The illustrations presented in Figures 1.1, 5.3, 6.3, and 7.2 indicate the developments and refinements that were made after each phase of the research trials. The flexible nature of the SLDP allows further developments and adaptations to be made. For example, three text checkers were designed, and a topic module in biology was added, after the second extended study. The text checkers were a spelling checker, a grammar checker, and a document statistics counter. The spelling checker was made specific to the topic in each module, but can be adapted to the requirements of the user, as can the grammar checker.

The HCP modules also were gradually developed and refined over the three phases of the research. At the completion of the research, a number of modules were completed in physics, chemistry and biology as follows:

* physics topics: electricity, magnetics, heat energy, nuclear radiation, light, electromagnetic radiation, dynamics, sound.
* chemistry topics: acids in pollution, metals.
* biology topic: vertebrate animals.

The components of SLDP are capable of further development and can be adjusted to the needs of other users.

The Third Research Question:

What is the general effectiveness of SLDP? This question implies further sub-questions: How can general effectiveness be assessed? Does the general effectiveness of SLDP apply across all levels of student writing ability? Can the SLDP be incorporated into individual teacher's course schedules?

The trials with SLDP produced an extensive range of genres of scientific writing. These genres were:

* reports, mainly biographical accounts of scientists or scientific discoveries;
* recounts consisting principally of laboratory reports and research assignments;
* procedures for the design of investigations;
* explanation contained mainly in essays;
* discursive argument for the discussion of opposing hypotheses;
* and other literary forms such as poems and letters.

The HCP modules provided a pathway to each of these genres in different HyperCard *stacks*, but only one of the pathways, namely, that to the explanation genre, was fully developed. In order to carry out trials to establish the degree of effectiveness of SLDP, its use was restricted to the explanation genre as design restriction. This enabled some comparison to be made with similar writing exercises done in similar circumstances by students not having the experience of SLDP.

The general effectiveness of SLDP was judged by an assessment scheme that was independently developed for assessment of explanation genre essays. The scheme, called Scientific Explanation Genre Assessment Scheme (SEGAS), was developed from the taxonomy of Structure of Observed Learning Outcomes (Biggs & Collis, 1982). It allows a scorer to progress logically through unistructural, multistructural, and relational to extended abstract criteria, resulting in the award of any one of nine grades from C- to A+ on criteria that combine both scientific and linguistic indicators. The SEGAS was found to be reliable for use independently of this research and could be used for essays not written under SLDP program as well as with SLDP.

The results of assessments using this instrument indicated that there was a significant difference in the improvement of students using SLDP compared with those not using it. Experimental trials in the second extended study were carried out with a time-series design in which two writing tasks were assigned before the SLDP experience and two writing tasks after using SLDP. Similar writing tasks were assigned to a control group and the same manner of assessment was applied. The results showed that both control and experimental groups improved significantly during the course of two semesters, but that the experimental group's improvement was significantly greater than that of the control group. This improved performance was matched by a more positive attitude to writing in science by the students, as indicated in three student questionnaires and a number of student interviews. The enjoyment of writing physics essays was deemed greater by the experimental group after SLDP than a control group, and the assistance provided by concept mapping, provision of definitions, contextual readings and model essays, was found to be helpful to the experimental group. The improved performance at writing in science was shown in the pilot study to have had no adverse effect on the level of students' content knowledge of the topic. In post-SLDP questionnaires of both the first and the second extended studies, teachers generally rated the components of SLDP highly effective. The voluntary incorporation of SLDP into course schedules by two teachers was a further indication of the acceptance by teachers of its effectiveness.

The general effectiveness of SLDP was tested across a range of levels of ability. A scale, called the writing-in-science potential (WISP) scale, was devised to test the effectiveness of SLDP over the seven levels of this scale. While some of the sub-groups were too small to assess adequately the effect of SLDP within it, the general trend indicated that the SLDP was effective for all levels and more effective for middle and lower ability students. Evidence from the trials also indicated that SLDP was equally effective for males and females. The effectiveness of SLDP for students with NESB was also supported by trials with classes of recent migrants. Scientific writing was improved despite the difficulties with the conventions of English.

Fourth Research Question:

Is the effectiveness of SLDP related to specific elements in the proposed definition of scientific literacy?

The use of hypertext facilities, in this case HyperCard, is one way to activate the cognitive processes of students, the first element of the definition, and to link language usage with conceptual development. Representational schema with links and nodes establishing superordinate, subordinate and associative links between concepts were used with computer-assisted concept mapping. The concept mapping was done using multiple pathways, which enabled students to use prior knowledge, concept definitions, and contextual reading texts to produce a piece of extended writing. Analysis by the researcher of concept map structures indicated that they provided a scaffolding for text processing strategies for many students, and hence provided a means to develop proposition-based compositions in contrast to topic-based compositions. The use of multiple pathways within the HCP modules was analysed and then compared with the subsequent writing performance. There was some correlation between the mean number of pathways used throughout the exercises in HCP and the grade achieved. The frequency of pathways used by students increased with grades achieved from C- to B+. The same correlation was not evident for the A-, A, and A+ grades, perhaps indicating that these students did not require the use of multiple pathways to the same extent as the lower achieving students.

Examination of the second specific element in the definition of scientific literacy, namely, the engagement in the discourse of science, was somewhat limited by the setting of this research and by the research design. Ideally, the discursive argument genre would be used to foster the engagement of relativist and rationalist approaches. The SLDP could be adapted to meet the needs of the scientific discursive argument. For example, exercises in paragraph writing and structure of argument could be introduced in the lesson pattern. Concept mapping could take a different form such as one with more lateral inter-connections with each argument from one side being systematically refuted by the argument from the alternative viewpoint. The SLDP with its accompanying HCP model of writing is thus adaptable to the discursive argument and hence to the development of relativist and rationalist discourse. However, this research study examined the use of the explanation genre in scientific writing, for the important reason that this was more relevant to the needs of Year 11 students in mainstream science courses. The use of the contextual readings in the HCP modules did expose students to a variety of genres which assisted in the critical examination of some of the issues assigned to students in the reading and writing tasks.

Investigation of the third specific element of the definition, namely, the use of the language register of science, was addressed with specific lessons in language acquisition, with teacher-student duologue, and with the composition of writing pieces. The results indicated a significant difference between experimental and control groups in the use of specialised vocabulary and the use of logical connectives. There was no significant difference in the use of quantitative expressions in the writing pieces of the two groups, and the use of diagrams, graphs and tables, although infrequently used, was significantly greater in the control group. This problem relates to one of the limitations of the software, namely, the difficulty of using *graphic tools* within *text fields* of HyperCard for these illustrations. The analysis of duologue at computer work stations indicated an increase in the ratio of student to teacher use of elements of the language register of science when compared with regular classroom dialogue. The elements analysed were the use of scientific concepts, relational statements, and applied examples. This result supported the claim that SLDP was a factor in enhancing scientific literacy.

The HCP model of writing provided a communications strategy, an element of the definition of scientific literacy, to easily make the transition from knowledge-telling to knowledge-transforming genres of writing. Analysis of navigational pathways employed by students indicated different sequences of navigation, and it is presumed that cognitive processes occurred during all stages of composing including generating ideas, structuring of concepts, language production, editing and evaluation of the product.

In regard to the specialised conventions of English usage, the SLDP incorporated the requirements of the South Australian Writing Based Literacy Assessment (WBLA) for coherence and cohesion. Under the assessment scheme (SEGAS), the same classification of the WBLA conventions for Requirements Not Met was used. After the trials, development of three checkers to assist with the specialised conventions of English usage were developed. The checkers were a spelling checker made specific to each topic, a grammar checker that could be made to serve specific difficulties, and a statistics document checker for simple aspects such as length of sentences, use of paragraphs, and use of complex words. The use of these checkers was not tested empirically, but comments from teachers were surveyed and these were favourable. The SEGAS incorporated a further nine grades of assessment that included linguistic features at each grade.

The three levels of computer-assisted writing described in the literature were thus incorporated in the HCP writing model. They were: first level word processing for deletions, substitutions and rearrangements of text which lead to better drafting techniques; second level post-writing editing for spelling, grammar and writing style checks which lead to better revising techniques; third level hypertext procedures for interactive routines for assisting throughout the composing process such as planning, organising and linking which lead to better knowledge-transforming techniques. According to Hartley (1993) development of the third level of hypertext transitions in writing processes is in its infancy and hence this research makes a significant contribution to the field.

Practical Outcomes

The most significant outcome of this research was a set of curriculum materials that can be adapted by teachers for future needs. The materials produced were: the SLDP program supported by a Teacher's Manual and Lesson Packs, the HCP modules on separate computer discs, and the assessment scheme, SEGAS, for the grading of explanation genre essays. In addition, the study has produced an example of classroom research supported by full documentation in the appendices of this thesis.

The SLDP Program

The SLDP is a program of 12 lessons which can be used as a block of lessons, in which each lesson can be integrated into the course schedule at different points. It is possible to reduce the 12 lessons used for the first topic to fewer lessons for subsequent topics, depending on the ability and progress of the students. The implementation of the SLDP requires at least six lessons to be taken at computer work stations. However, the HCP modules are self-directing and hence students can work through the module at other non-assigned class times or at home (if equipment is available).

Teacher's Manual and Lesson Pack

The Teacher's Manual contains detailed plans for each of the 12 lessons of the SLDP program. It contains a trouble shooting section and an advanced user's section. It contains the SEGAS assessment scheme and the concept map assessment scheme as well as some examples of concept maps and paragraph writing.

The lesson pack consists of a number of overhead transparencies for each lesson of SLDP made specifically for each topic. They were produced as an example only and teachers are encouraged to produce their own lesson packs which will reflect their own needs and those of their students.

The HCP Modules

Each topic module is copied on to individual computer *discs*. These *discs* can be installed on the *network* for use in work station folios or copied on to individual *discs* for personal use by students. In this way, students can store their topic summaries, concept maps and essays. Each HCP module consists of three HyperCard *stacks*, one to commence the program, modify the menus, set the *userlevel*, and modify the keyboard. The second *stack* contains the concept mapping learning instructions, the contextual readings, the writing models, the assessment scheme and the unlocked fields for the writing/typing essays. An option is the inclusion of text checkers. The third *stack* contains eight *cards* for essay concept maps, which can be extended into further *new cards* if required.

Scientific Explanation Genre Assessment Scheme

SEGAS can be used independently of SLDP and is a scheme to allow teachers to grade the quality of scientific writing in the explanation genre according to criteria related to both scientific and linguistic features. The scheme is based on a well documented taxonomy (Biggs and Collis, 1982), and identifies clear attainment levels in terms of logical presentation and development of concepts associated with greater sophistication of language use. The nine point scale can be converted to other assessment scores according to the needs of the user. After some induction to new users, SEGAS can be used reliably.

Classroom Research Method

The classroom research method developed in this research could be used for other similar research. The researcher followed the ethical steps required to conduct classroom research and gained the confidence of the participating teachers and students. These steps included the Agreement for Privacy provisions, anonymity, member checks, and a project termination process. The researcher found it necessary to be closely associated with the groups involved in the study in order to maintain the commitment by the participants. Upper secondary curricula in South Australia are arranged in semester units; hence any research over a period longer than one semester is likely to meet problems of sample mortality.

Fully Documented Appendices

The appendices of this thesis contain various student and teacher questionnaires, examples of student work, assessment schemes, a Teacher's Manual, a teacher's course schedule, and the programming script of the computer-assisted HCP modules. These may serve as a guide to future researchers in the area of computer-assisted learning projects.

Limitations and Interpretations

Although this research project commenced with a comprehensive definition of scientific literacy, it became necessary for reasons of practicality, to limit the research to classroom research. This in turn requires acknowledgment of the limitations of the research design, issues relating to data collection and analysis, and the interpretational nature of the findings.

Limitations from the Research Design

There are five limitations to be considered in interpreting the findings of the study. The limitations relate to: researching only one genre of scientific writing, using only one Year Level and topics within one subject, consequences of the nature of the sample, consequences of the sample size, and the practical limits imposed by the computer equipment and software. These limitations are briefly described in the following paragraphs.

Only one genre of scientific writing. This limitatiion was not at first planned, but became necessary after the review of the findings of the first extended study. The findings showed that a single assessment method could not be used over a variety of genres, and therefore student performance between experimental and control groups could not be compared when they had written in different genres. The limitation of using one genre of scientific writing was imposed in the second extended study and enabled comparisons to be made more readily between experimental and control group performances.

Topics at one Year level only. Even though problems with literacy were revealed in Year 10 and Year 12 from WRAP and the Gilding Enquiry respectively, for reasons of practicality, this research was limited to physics (and later some chemistry) topics in Year 11 classes. It was impractical to ask Year 12 teachers to put aside 12 teaching lessons to trial the unproven SLDP program. The Year 12 academic year is also shorter because of the constraints of public examinations. At the Year 10 level in South Australia, there is no standard course in any one of the science subjects at this level. This would have made comparative evaluations impossible to carry out. Classes from the Year 11 level were used in both experimental and control groups in the three phases of the research.

Nature of the sample. It was not possible to select the experimental and control groups for each trial sample to produce a stratified random sample of the population of Year 11 physics students, as was achieved for example, in the Writing and Reading Assessment Program (Education Department of South Australia, 1992). This limitation was a result of criteria-based selection of participatory schools. These criteria were the type of computer equipment available at schools, the willingness of teachers and school authorities to be involved, and the city location of the schools for travel reasons. Within these criteria, every attempt was made to select schools that represented a range of schools according to socio-economic background, single sex and co-educational schools, and availability of different types of computer facilities. The range was achieved across seven different schools in the experimental group and four different schools in the control group in the second extended study.

The sample size. The sample was restricted to four schools in the pilot study and increased in each of the subsequent phases, the first extended study and second extended study. The limitation on sample size was determined by the workload for a single researcher. In the second extended study the sample was large enough to apply descriptive statistics for multivariate analysis of variances between the experimental and control groups. The sample size was not large enough for an adequate statistical treatment of the results of the sub-groups according to the seven bands of WISP.

Computer equipment and software. The equipment limitation to the applicability of SLDP is a result of the current state of development of hypertext facilities in mainstream school type computers. At the time of this research only one suitable hypertext software package was available and affordable for school use. That was HyperCard. The SLDP was based on the computer-assisted activities described above, and therefore it employed the HyperCard platform. With further development of other hypertext systems it would be possible to convert the program *script* for application to other brands of computers besides *Macintosh*.

Issues Relating to Validity and Reliability

The precautions taken to counter the threats to internal and external validity and reliability are summarised briefly here.

Internal validity. Five basic strategies were employed to ensure internal validity. They were: triangulation of data analysis, member checks with the participants, long term observations, peer examination of interpretations, and a certain degree of participatory action within the development of SLDP. It seems reasonable to claim on the basis of the quantitative and qualitative findings, and within the precautions taken, that SLDP did improve the performance of writing in the explanation genre in science more than did the conventional strategies. However, one of the assumptions underlying qualitative research is that reality is wholistic, multi-dimensional, and ever-changing (Merriam, 1988). Hence, the claim of internal validity for the effectiveness of SLDP is situational, that is, the claim applies to this research study only. On the other hand, the SLDP was made to be adapted to meet new circumstances and therefore it can be made effective in new and different circumstances.

Reliability. The precautions taken to ensure reliability of the research design were adhered to as far as was practicable. These were establishing the independent reliability of the measurement instruments such as the SEGAS and the concept mapping scoring scheme. Triangulation of data collection and analysis using both quantitative and qualitative methods gave positive indication about the effectiveness of SLDP, and the correspondence of SLDP with specific elements of the definition of scientific literacy. Extensive reporting of all developmental and evaluation aspects in both the body of this thesis and in extensive appendices provide what is termed an audit trail, which can be used in any future replication of the study in whole or in part.

External validity. The claim for external validity can be made within the parameters of this research. That is, the effectiveness has been demonstrated for Year 11 physics (and in limited cases, chemistry) students from schools that met the conditions for each phase of the trial. The sample schools represented a range from low to middle socio-economic backgrounds. The willingness to participate in the study by the schools in the sample of each trial phase was a common factor in these groups of schools. A third parameter was the availability within schools of the required equipment. External validity of the research design allows extension of the interpretations to schools similar to those in this sample.

Interpretational Nature of the Study

The interpretations of the study were influenced by the dual role of the researcher (as participant and observer), the difficulties encountered because of the nature of classroom research and by the nature of assigning writing tasks to students in different classes in different schools. The advantages of participant observation also influenced the interpretations of the study. These influences are discussed in the following paragraphs.

The role of the researcher. The interpretations of the study were influenced by the dual role of the researcher as both participant in the development and as observer in the evaluation of SLDP. The researcher cannot help but affect, and be affected by, the setting and interaction within the research activities and this may lead to distortion of the real situation. According to Merriam (1988), "The schizophrenic aspect of being at once participant and observer is a by-product of this method of data collection not easily dealt with" (p. 103). Some strategies were employed to ensure objectivity as much as was possible. These were to incorporate procedures of anonymity in the collection and analysis of data, to produce interim reports for participants and for external checks by the research supervisors, and to observe ethical procedures in the reporting of findings. Other precautions advised by Merriam (1988) were built into the research design. These were the provision of a rich description of events, provision of typicality of research sites, and the amalgamation of cross-site analyses. These strategies are reported in the body of the thesis, and the data are given in the appendices.

The nature of classroom research. The progress of the research was hampered by a number of classroom difficulties that commonly occur in the day-to-day operation of schools. For example, on occasions there were malfunctioning computers; altering time-tables, class schedules and computer rooms schedules; teachers not observing the exact procedures in the lesson plans; teachers making mistakes in the teaching of some English language conventions; inconsistent student behaviour influencing the writing performance. Classroom events such as these were not conducive to achieving control of all variables. Nevertheless, the collection of data and the interpretation of its meaning were made as consistently as possible.

Nature of assigned writing tasks. although the assessment status of each writing task was required to be either formative or summative components in the course evaluation, it was not possible to have exactly the same importance placed on each writing task for all groups. The participating teachers in the experimental and control groups during the second extended study agreed to set the explanation genre essays from a suggested list of titles. However, not all teachers introduced the writing task in exactly the same way, nor did the students in all groups respond in the same manner. This was best monitored by the researcher adopting a role of participant observer.

Participant observation. Guba and Lincoln (1981) describe the advantages of the 'human instrument', such as a sensitivity to motives, beliefs, concerns, interests, unconscious behaviours, tacit and propositional knowledge. A particular advantage of participant observation during the trial phases, was to enable the researcher to determine the adaptations and refinements required in the development of the SLDP program. The progressive development of the computer-assisted scientific literacy program was possible largely through information gained from the researcher's role of participant observer.

Implications of the Study

There are implications of this research study for educational practitioners and research workers.

Educational Implications

This research study has provided a comprehensive definition of scientific literacy at a time when literacy across all curriculum areas in secondary schools is being made a priority in South Australia. Scientific literacy was an objective within the broader definition of literacy provided by the National Consultative Council for the International Literacy year (Hartley, 1989). It was described as an active literacy which allowed people to enhance their capacity to think, create and question, in order to help them participate effectively in society.

The Definition

In the earlier literature, scientific literacy was defined in terms attainment levels within a number of areas of concern. Attainments were about the level of science knowledge and understanding, or the level of concern expressed about the impact of science on society, or the level of language skills required in the communication of science. The educational significance of the definition proposed here is that it is defined in verb phrases relating to the functions of being human. As such, the definition is a dynamic one and is not a measurement of levels attained but rather a description of what activities are taking place.

Scientific Literacy Development Plan (SLDP)

The components of SLDP, language acquisition, concept mapping, duologue and strategies, and the HCP modules, were developed, refined and trialled over three phases of classroom research. The Teacher's Manual, and the supporting lesson packs indicate how strategies for enhancing scientific literacy can be integrated into regular course schedules. Instructions for teachers to adapt the HCP modules for other physics topics and other upper secondary science courses are included in the Manual.

Evidence from this research shows that teachers were able to use the components of SLDP effectively and to incorporate them into regular course schedules. Although the components can be used discontinuously, the computer-assisted nature of the modules integrates all aspects of the SLDP. The use of SLDP over a number of different topics allows for a reasonably continuous process of activating cognitive processes in the discourse of science and communicating this discourse in a language register of science.

The HyperCard Pathways (HCP) Model for Scientific Writing

The computer-assisted design within SLDP allows teachers to use innovative technology within regular course schedules. The HCP model of writing is an application of a hypertext system, that is, an electronic system to create interconnections, called navigational pathways, between texts. This model of writing allows for the composition processes of writing, that is, planning, generating, organising, translating and reviewing, to be undertaken continuously and in any order. Students create their own pathways between the composition processes. Concept mapping is one facility made available to students for some of the composition processes. One feature of this writing model was the provision of contextual readings with the selecting facilities in HyperCard able to take concepts from contextual readings, and then to transfer them to concept maps during the compositional processes. The pathways to relational statements, definitions of concepts, and links with prior knowledge are available to students at any stage of the writing composition.

The significance of the HCP modules for teachers is that little previous experience with HyperCard is necessary because a fully *scripted* program enables all of the compositional processes to be obtained through interlinked *buttons*. Students with more advanced skills in HyperCard would be able to use the HyperCard Pathways techniques to expand topic modules in much the same manner as would skilled teachers. Also, the use of this adapted version of HyperCard can lead students on to create their own *stacks* by using similar techniques. The HCP model of writing could be classified as an application of constructivist pedagogies because of students' independent use of navigational pathways.

HyperCard Pathways (HCP) Modules

Eight topic modules in physics, two in chemistry and one in biology have been developed. Each module is self-contained and modules may be used in any order by teachers. The modules need not necessarily be used only for writing; they can be used for creating concept maps, semantic nets, and other information storage networks. The modules are *scripted* in such a way as to allow teachers, even those with little HyperCard experience, to adapt and create new modules in any topic. Within each module, new concepts, new contextual readings and new models of writing can be added by using the adapted menus of HyperCard. The significance for students is the flexibility of using any part of the module and in any order that they wish.

The navigational pathways give students a method of creating structure, propositional statements and links between concepts; the creation and storing of concept maps; techniques such as spelling, grammar and counting checkers for specific problems for ESL students; the use of concepts from contextual readings; the use of assessment criteria which allow students to draft, edit and check their writing.

Scientific Explanation Genre Assessment Scheme

The significance for students is that a well defined assessment scheme is available to them before and during the work of composition. They can review the criteria themselves and seek advice as they progress in the writing task. A further significant factor is that SEGAS incorporates the WBLA criteria (mandatory for the Award of Certificate of Education in South Australia). Thus students can complete the required pieces of writing for WBLA using the HCP model of writing and be assessed according to SEGAS.

The progress of students can be charted by teachers, as their scientific thinking and writing develops through the concrete-symbolic mode towards the formal mode as described by Biggs and Collis (1982). In its present form the assessment scheme also provides a basis for development of assessment schemes in other genres of scientific writing.

Research Implications

Classroom Research

An example of classroom research is provided by this study. In spite of the difficulties inherent in this form of research, the model of participant observer seems to have been successful. The ethics of classroom research are of paramount importance, not only for this study, but also for any subsequent study. Close contact with *in situ* situations and member checks with regard to data collection and analysis, enables a good rapport to be established between the researcher and the participant teachers. This was necessary because of the extensive duration of the trials, particularly in the case of the second extended study. The documentation within the body of this thesis and in the appendices provides a model for future research projects in regular classrooms.

Further research could be undertaken in three areas: development of more topic modules, a longitudinal study on the effects of SLDP so that its effectiveness could be investigated in relation to the public examination results, and development of assessment schemes. Recommendations in the conduct of classroom research are summarised as follows:

* Observe the correct protocol for approval to conduct research in a school. Teachers and students need to be informed of the research and invited to participate. All collected materials, such as essay writing should be returned promptly to the students. Gain students' approval for the photocopying of any student material. Students should be informed of the status of any assessment by the researcher of their work. These procedures were followed in this research.

* Provide specific instructions, detailed lesson plans and other support materials for teachers who may be involved in presenting aspects of the research. Acknowledge the contribution of the participating teachers. During the course of this research project a lesson learned from the first

extended study was that more specific guidelines had to be given in the second extended study for the writing genres required.

* Adopt the role of participant observer and induct the participating teacher into the same role. Share all aspects of data collection and analysis. Check interpretations with the participating teacher before publication. During this research, a change of classroom teacher caused difficulties with data collection. Closer participation by the researcher would have alleviated this problem.

* At the termination of the project, suitable reports need to be made to the schools' authorities, the participating teachers and the students, with suitable acknowledgments. This was done in this project.

Some research implications may lead to further possible projects to extend the findings of this research. Other projects may include a further longitudinal study, extension of topic modules, development of other assessment schemes, and development of another hypertext model of writing suitable for other computer systems.

A Further Longitudinal Study

A longitudinal study of the effects of SLDP over a two year period, that is throughout Year 11 and Year 12, would provide evidence of any possible long term effectiveness of SLDP. The results in the public examinations for literacy dependent questions could be compared with results from a similar group of students who would act as a control group undergoing the same conditions apart from the application of SLDP, over the same period. The report of the difficulties experienced in this research project would be a guide to the planning of such a study.

New Topic Modules

Further topic modules could be developed in physics, chemistry, biology and geology to assess the effectiveness of these modules on the writing aspect of scientific literacy. The same program could be applied by teachers of chemistry, biology and geology as have been applied in this research by physics teachers. Such developments would assist students with meeting the criteria for the Writing Based Literacy Assessment (Education Department of South Australia, 1992).

Other Assessment Schemes

Assessment schemes for genres other than the explanation genre of scientific writing could be researched, developed and trialled. Such schemes would allow a broader understanding of the contribution of other scientific genres to scientific literacy. In particular, research into the development of a scientific discursive argument genre scheme would provide a guide to students to access the discourse of science more adequately than did the use of the explanation genre in this research. Contextual readings within the HCP modules can provide a focus for this genre of writing.

A Pathways Model for Other Computer Systems

The hypertext approach to the composition processes of writing can be developed for other computer systems. A number of alternative approaches have been reported in the literature. The task for a future classroom researcher would be to adapt these alternative approaches to the specific needs of students and teachers. This research serves as a model for adapting a computer software package to the immediate needs of a group of teachers and students.

Conclusion

A comprehensive definition of scientific literacy formulated from a synthesis of theories expressed in the literature has been provided to teachers, students and science educators. The hypothesis that a scientific literacy development plan, developed here as SLDP, incorporating a HyperCard Pathways model of scientific writing, is an effective way of enhancing scientific literacy, was vindicated within the parameters of this research project. The improvement in writing in the scientific explanation genre by students using SLDP was shown to be greater than the improvement shown by students using conventional practices, as far as the quasi-experimental nature of this research permitted. The continued use of the SLDP by some teachers beyond the life of this research project is an endorsement of its effectiveness and practicality.

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G.

Science and Mathematics Education Centre

A COMPUTER-ASSISTED SCIENTIFIC LITERACY DEVELOPMENT PLAN FOR SENIOR SECONDARY STUDENTS

Volume 2
(Appendices)

by
Patrick Joseph Cronin

This thesis is presented as part of the requirements for the award of the degree of Doctor of Philosophy of the Curtin University of Technology
1994

LIST OF APPENDICES

Appendix 5.1
Year 12 Literacy in Science Survey

The basis for the design of this student questionnaire was the assessment framework developed by the South Australian Assessment of Writing and Reading In-service Teacher Education project team. The framework included broad criteria for assessment of Concepts, Attitudes, Aspects, Strategies and Range of students' literacy (CASSR). These assessment criteria were adapted in this questionnaire to gauge students' attitudes towards writing and reading in science compared their attitude to writing and reading in other subjects. The questionnaire was given to Year 12 students at the end of their course. They could thus make responses based on their experience of the total course. This appendix is a copy of a typical response.

Year 12 Literacy in Science Survey

NAME OR NUMBER ______________

SUBJECTS : ENGLISH (✓) BIOLOGY (✓) PHYSICS (✓)

1. If you do English/Physics/Biology, which essays do you prefer to write: English/Physics/Biology.

   (a) Biology

   (b) Why? Because English essays are specific to several texts and requires comparisons. Biology essays are enjoyable to write. I think its because I like Biology better as a Subject

2. Physics/Biology students, which section of the paper do you prefer A, B, C.

   (a) Put them in order of preference Biology : B, C, A

   Physics : A, C, B

   (b) Why? I like answering short answers better than multiple choice answers, I ~~a~~ think I like essays and multiple choice about the same

3. In what ways are you expected to write differently in Physics than in Biology than in English?

   In physics and Biology they both include reciting facts and relating what youve learnt about the body or experiments. In English you need to evaluate texts, find symbolism, imagery, contrast social concerns. English Essays are more complex.

4. Where do you read or see about scientific things other than in text books?

   Newspaper

   T.V - Beyond 2000

Appendix 5.1

5. Rate the following aspects of your <u>writing</u> in English, Physics and in Biology with 3 or 2 or 1 or 0 for each sentence in each column.
3-highest.

	ENGLISH WRITING	PHYSICS WRITING	BIOLOGY WRITING
COMMITMENT TO WRITING Teachers also want to know about students' willingness to :			
* write drafts and then re-write a final copy	2-3	1	2
* assume responsibility for meeting deadlines and making self-corrections	3	3	3
* make changes by exploring alternative beginnings and endings	3	1	1
* ask for help and feedback and accept challenges	3	2	2
* give the larger concerns of ideas and information priority over spelling and grammar	3	1	1
* ignore distractions and stay on task, when working alone or with others	3	1-2	1-2
* share your writing with others, discuss insights, accept advice and give suggestions to others	3	1	2
* be critically reflective and use your past experiences to shape future writing	3	2	2
* write in Non-English language sometimes	0	0	0

3 - highest

6. Now rate the following aspects of your reading in English, Physics and Biology with 3 or 2 or 1 or 0 for each sentence in each column.

	ENGLISH READING	PHYSICS READING	BIOLOGY READING
COMMITMENT TO READING Teachers wish to find out about students' willingness to :			
* choose books and other reading matter beside the text book	1	3	3
* assume responsibility for choosing reading matter in this subject	1	3	3
* use a dictionary, index or glossary to find the meaning of new words	3	3	3
* ask for help and advice from peers, teacher, librarian	2	2	2
* find the books in the library interesting and helpful	3	3	3
* ignore distractions and stay on task .	3	1	2
* share your reading with others and discuss insights, opinions, interpretations	2	2	2
* be critically reflective and use your own knowledge and experiences to compare texts	3	1-2	1-2
* read in Non-English language as well as in English	0	0	0

7. For those who do Chemistry or Geology, would you like to see an essay type question come into the paper?

(a) N/A

(b) Why or Why not? N/A

8. Rate the following in order of preference for the way you learn English, Physics, Biology (1, 2, 3, 4, 5, 6, 7, 8, 9) down each column.

	ENGLISH	PHYSICS	BIOLOGY
Listening to the teacher.	2	2	2
Doing practical work.	N/A	1	1
Reading about the subject.	5	8	6
Writing about the subject.	6	9	7
Discussing the subject with friends.	7	6	4
Discussing the subject with teacher.	3	4	3
Watching TV.	1	3	9
Doing calculations.	N/A	7	8
Learning from text book.	4	5	5

Appendix 5.2
A typical lesson pack for one topic

This particular lesson pack of overhead projector transparencies was written for the topic "Sound". They were used as follows:

Pages 7 to 15 are copies of the transparencies made from the HCP computer program. They were used in lessons 1 to 4 of the SLDP in which the features of concept mapping were introduced to students.

Pages 16 to 17 are copies of the transparencies made from examples of students' first attempts at concept mapping with a teacher's comments.

Pages 18 to 23 are copies of the transparencies made for lessons 5 of the SLDP and used in the classroom to serve as a basis for language acquisition in elementary sentence construction.

Pages 24 to 25 are copies of the transparencies made for lesson 6 in the classroom to introduce paragraph writing.

Pages 26 to 27 are copies of the transparencies made for lesson 7 to introduce students to the strategies of using contextual readings and selecting concepts for the essay concept map.

Pages 28 to 31 are copies of the transparencies made for lesson 8 to introduce students to the writing task.

Pages 32 to 34 are copies of the transparencies made for lesson 9 to illustrate how a typical concept map is used to structure an essay and to establish a logical flow in the explanation of scientific concepts.

Pages 35 to 36 are copies of the transparencies for lessons 10 and 11 to prepare students for word processing skills in the typing of essays.

Click on this background button whenever you want to come back to this card.

1

To commence the program
CLICK HERE (Begin here)

To skip over to the reading
CLICK HERE (Reading texts)

To skip over to concept map
CLICK HERE (essay concept map)

To skip over to the writing
CLICK HERE (Writing task)

To skip over to the typing
CLICK HERE (essay typing)

Whenever you want to quit out of the program, go under FILE down to QUIT.

2

HCP Writing in Science

Hello Year 11 Students.
This program is designed to help you to read and write better in this particular topic of Physics. You will be mainly using this computer program but there will be some supporting classroom lessons. At the end of the program (12 lessons) you should have two well written essays that you can file away for your own use later.

This computer program is written in HyperCard hence the name HCP meaning "HyperCard Physics". Each screen is called a card and you click over with one click of the mouse button in the appropriate button.

CLICK OVER TO THE NEXT CARD NOW

(Click here to continue)

DECISIONS I

3

Before you start writing about a topic you have to make three decisions-

1. In what **genre** do you wish to write
2. In what **language register** do you wish to write
3. What **concepts** will you use

The following cards will help you to make these decisions

NOW CLICK OVER TO THE NEXT CARD

Whenever you want to quit out of the program, go under FILE down to QUIT.

(Click here to go back) (Click here to continue)

First decision: What Genre ?

4

There are 6 genres used for writing in science. They are:

1. **Recount**--- a story, like "one day in the life of Formula 1 driver". It may also be an account of an excursion on which you have been.
2. **Report**---a laboratory practical or an excursion. This is usually in a set form such as *aim, apparatus, method, results, conclusion.*
3. **Procedure**---as in a laboratory manual. It tells the reader what has to be done. You may use this genre when you write your own experimental design.
4. **Explanation**---often an essay. This is usually the genre required for Year 12 exams in Physics (and Biology).
5. **Exposition**---this is a scientific argument for your point of view about a contoversial topic.
6. **Discursive**---this presents scientific argument for two opposing points of view about a controversial topic. This is the hardest genre to write.

This HCP program is designed to help you with the last three genres: explanation, exposition, and discursive genres.

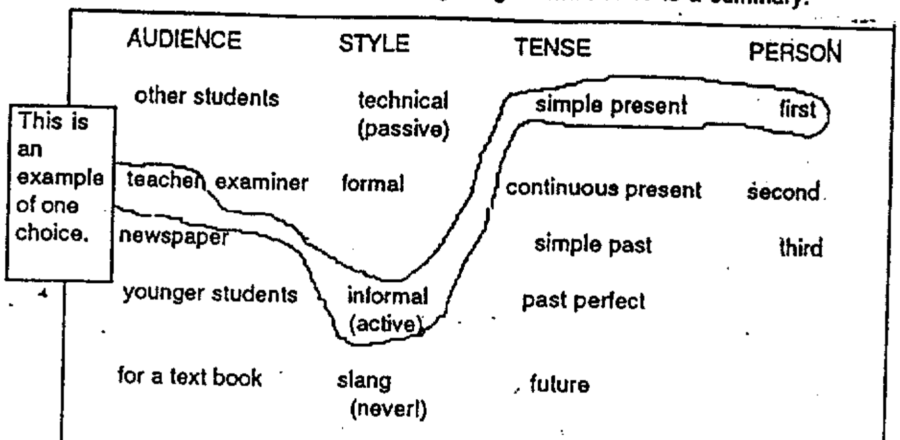
Let's start with an Explanation---an essay! CLICK OVER TO THE NEXT CARD

(Click here to go back) (Click here to continue)

Second Decision: What Language Register ?

5

The language register refers to the english grammar. Here is a summary:



We will come back to this later. CLICK OVER TO THE NEXT CARD NOW

Click here to go back

Click here to continue

Third Decision: What concepts ?

6

To help you build up your knowledge of concepts about **Physics** we use a technique called concept mapping. When you have made a concept map you can go about selecting concepts for your written genre:

A good way to commence concept mapping is to think of the way mountaineers climb. They look for likely tracks and intermediate levels on the way up. The next series of cards in **HCP** will teach you the technique of concept mapping as if you were mountaineering.

CLICK NOW OVER TO BEGIN YOUR MOUNTAINEERING !

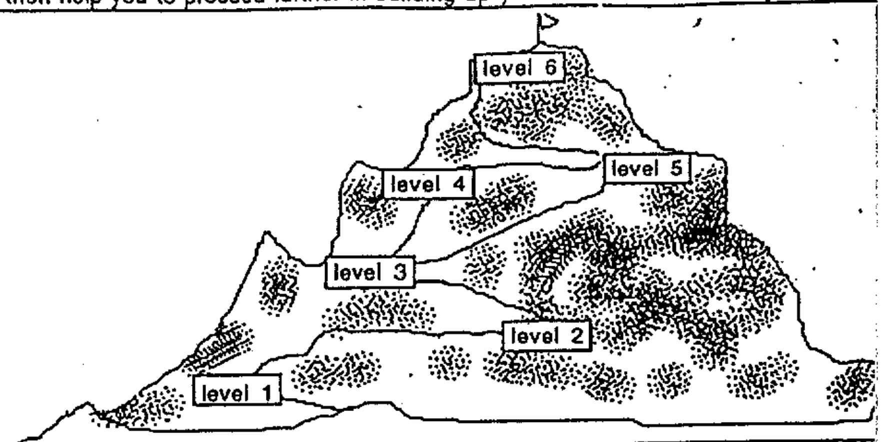
Whenever you want to quit out of the program, go under FILE down to QUIT.

Click here to go back

Click here to continue

Mountaineering 1

This computer programme (Hypercard) will help you make a map of all the tracks and levels in your mountain of knowledge of this Physics topic. It will help you make new tracks and ne levels on your way up the mountain. The programme will start at the level at which you are now, and then help you to proceed further in building up your mountain of knowledge.

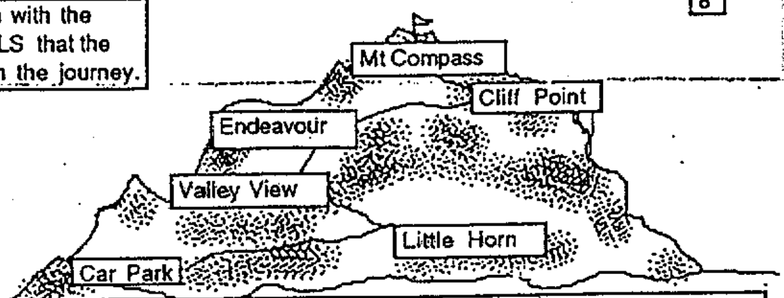


click here to go back

click here to contin

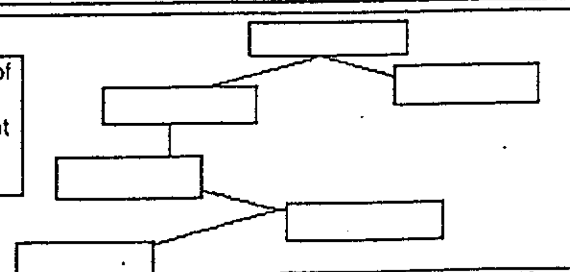
8

Here is a mountain with the names of the LEVELS that the climber reaches on the journey.



A stylised mountain of knowledge is called a *concept map*

Now *you* type the names of the mountain levels in the concept spaces. Don't forget to press return after you have finished each name.

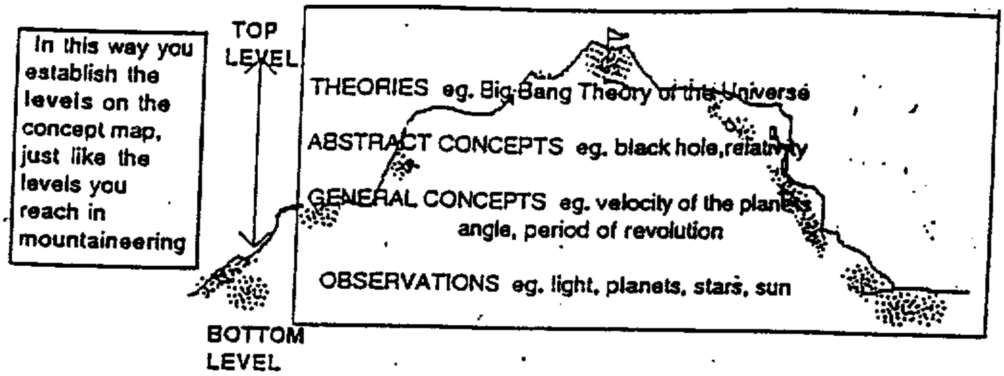


click here to go back

click here to continue

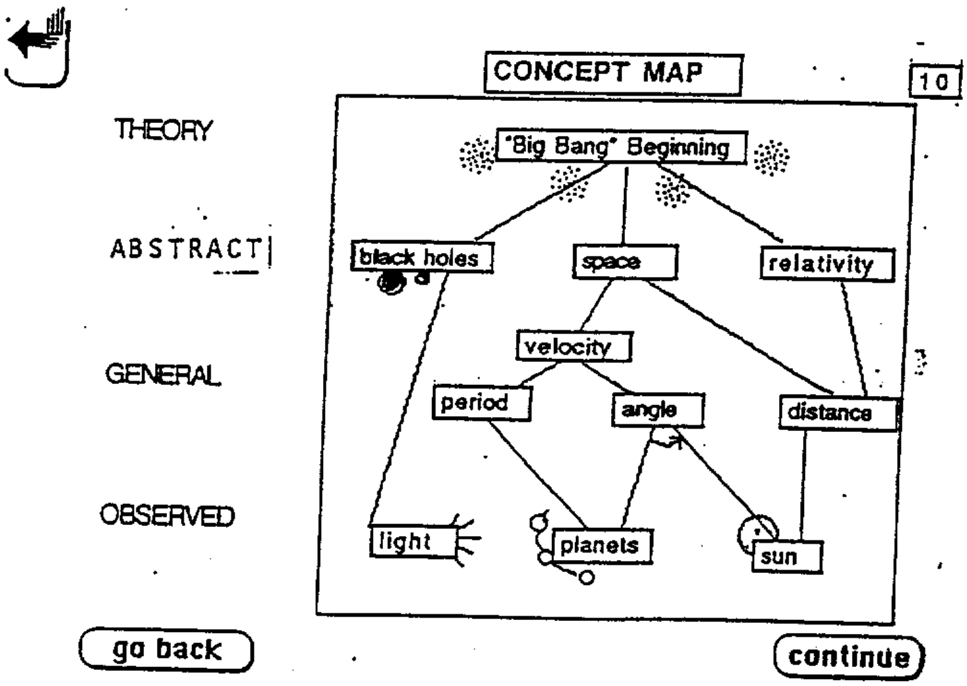
Good, now you know how to put your knowledge concepts on to a concept map.

In science, the ascending order of concept mapping goes like this:



Go to the next card for an example of this

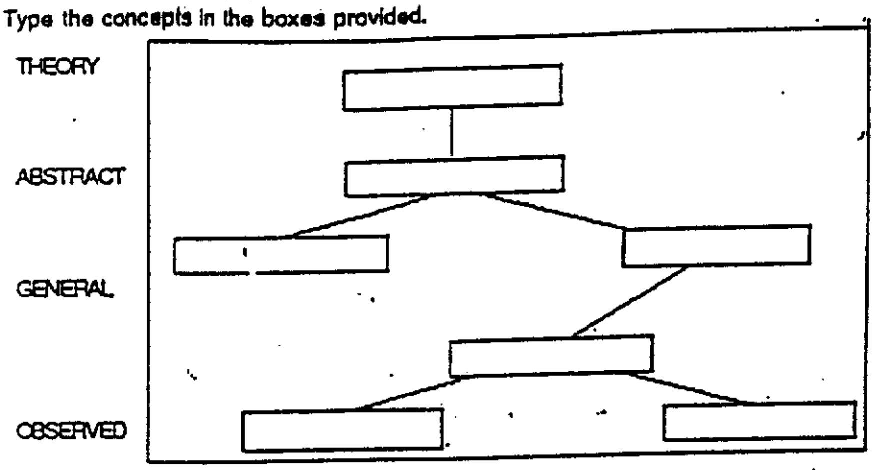
(click here to go back) (click here to continue)



11

Now you try making a concept map with the following concepts:
fish, living things, marine animals, food chain, shark, evolution, tuna.

Type the concepts in the boxes provided.

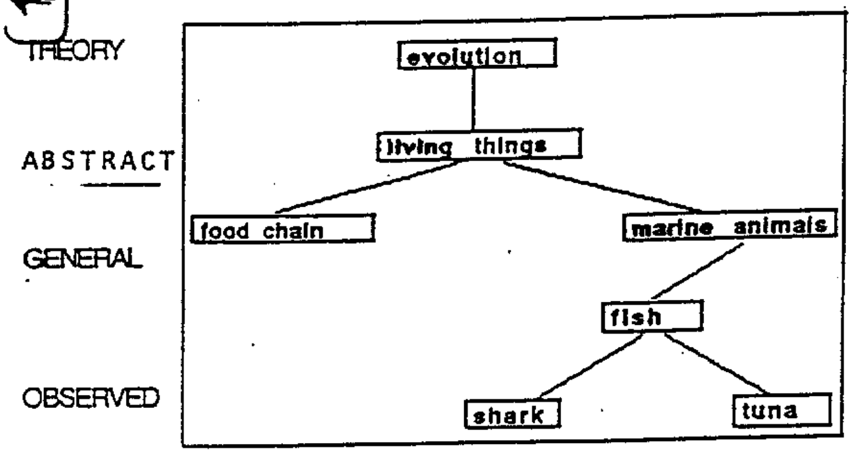


Click to the next page to see how your map agrees with HCP.

click here to go back

click here to continue

12



Notice how the theory is at the top, then general concepts down to the category of marine animals and at the bottom are the actually observed species of fish. You can go back to card 11 and correct yours by using the delete key and the return key and the mouse.

click here to go back

click here to continue

13

On your next card you will begin concept mapping your knowledge of sound. You will be presented with a list of concepts that you can arrange in your own way. Definitions of the concepts can be found by clicking onto the definition button • and holding the mouse button down. Try this.

reflection •
resonance •
decibel •
wavelength •
refraction •
longitudinal •
ultrasound •
doppler effect •
music •
frequency •
amplitude •

Now go on to the next card.

(click here to go back) (click here to continue)

14

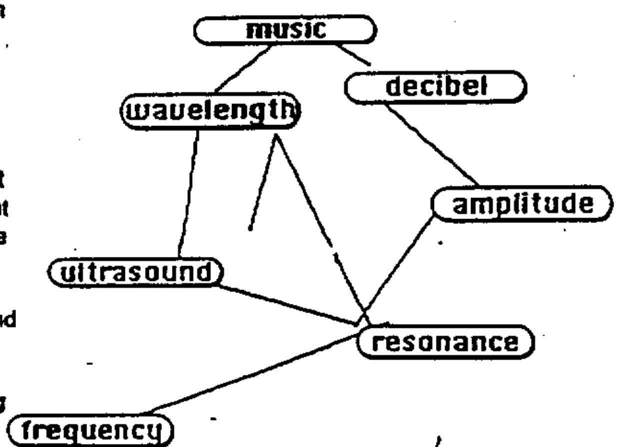
1. Open **Mapping** in the menu bar and drag the mouse down to **List of Concepts** and release the mouse button. This list will now appear in the menu bar.

2. Open **List of Concepts** and select a word.

3. Click on the concept and drag it (mouse down) to the place you want on the concept map and then release the mouse button.

4. Continue selecting concepts and place them on your concept map.

5. Now select line under **Mapping** in the menu bar and join up the concepts which are related.



(click here to go back) (definitions) (click here to continue)

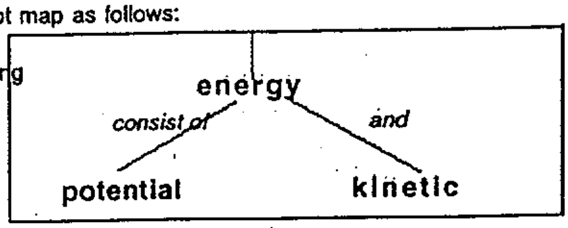
Now you are ready to begin *naming the tracks*. Remember the way to go from level to level on the mountain was by tracks. On concept maps these are called *relational statements*. We will use *Italic* typing for these.

They are phrases that connect two concepts. For example the relational statement between the concept enegy, potential and kinetic is:

--consists-- , *--and a--*

It is drawn on the concept map as follows:

This is reading from TOP down to BOTTOM.



GO ON TO THE NEXT CARD

(click here to go back) (definitions) (click here to continue)

16

Mountaineers would find a map of the tracks up to Mt.Compass very handy.They would know when they had reached **Cliff Point** or ***Valley View***. They would find it even more helpful to speak to others who had been there before. It is the same with the knowledge mountain. The *relational statements* tell the learner to move from one level of knowledge to the next.

The *relational statements* between concept levels are usually verbs or connectives or Physics rules. Here are some examples:

VERB PHRASES	CONNECTIVES	RULES
used in---	*F. for, further*	*in an isolated syst*
is an example of--	*A. and, again, added to,*	*∂p = mv - mu*
contains---	*N. not, nor, never*	*with vector sign change*
belongs to---	*B. because, therefore*	*by adding vectors*
is measured by---	*O. or, alternatively*	$V = I \times R$
is the property of-	*Y. yet, nevertheless,*	$W = F \times d$
causes---	*S. so, sometimes*	$c = f \times l$

GO ON TO THE NEXT CARD

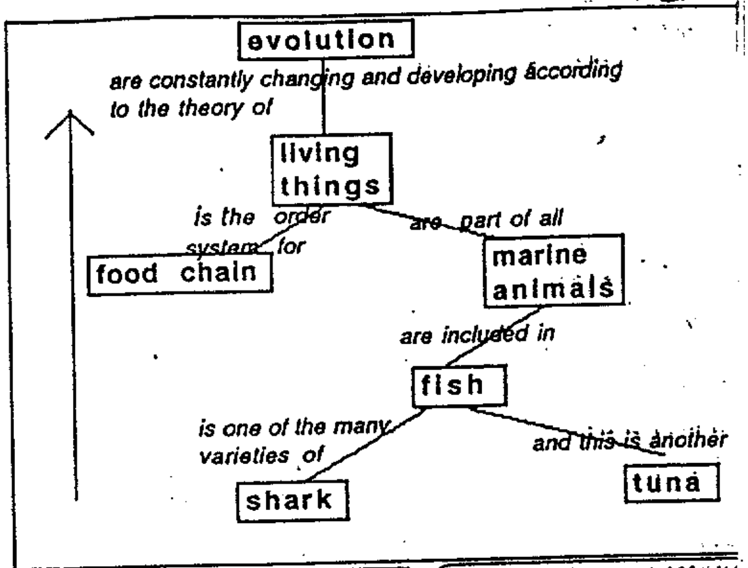
(click here to go back) (click here to contin

17

Here is an example of the use of *relational statements* in the fish concept map. Read the map from the BOTTOM upwards.

Can you extend this map using other concepts and making up your own *relational statements?*

Click over to the next card when you are ready.



click here to go back | GO ON TO THE NEXT CARD | click here to continu

18

1. Now using the List of Concepts build another 'el-mag spectrum' concept map. Place the concepts in the correct height order. You can make changes to the way you did it before.

2. Select line and draw in the connecting lines again.

3. Now open mapping again and select **relational statements.**

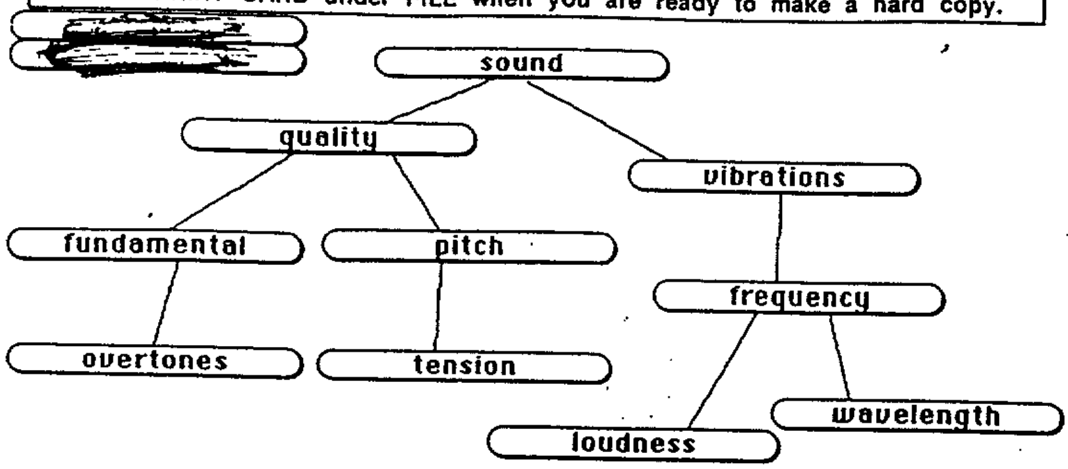
4. Select one *relational statement* for every connecting line. You can alter the words of the relational statement to make them fit the concepts better if you wish.

5. Drag the one you select to each connecting line.

6. You can erase if you wish.

click here to go back | definitions | click here to continue

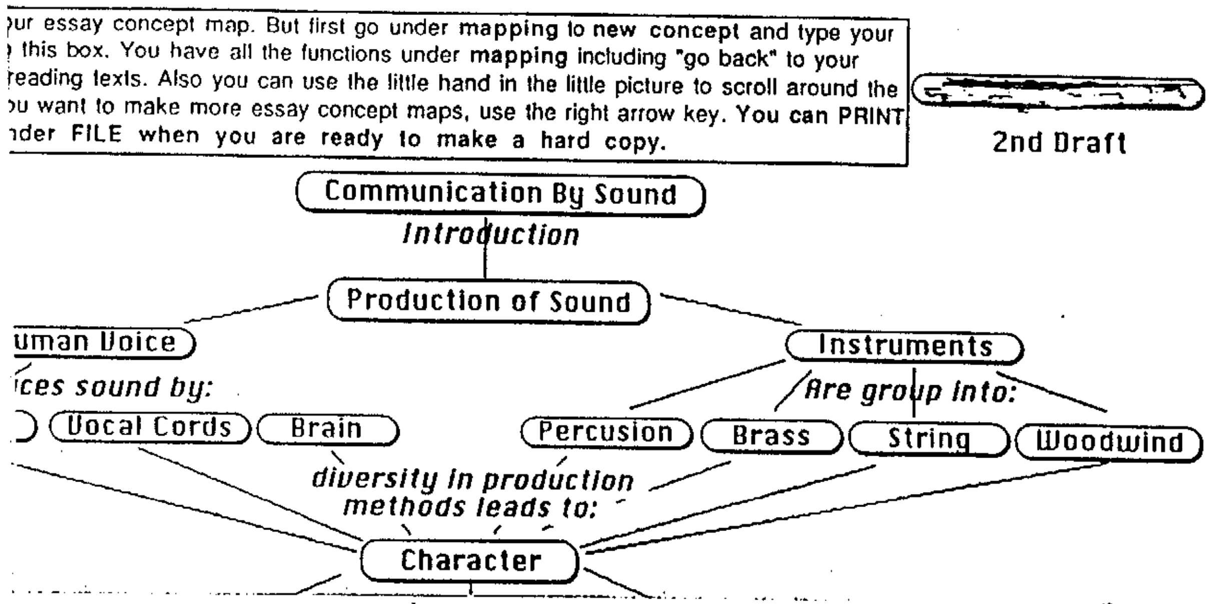
,his is your essay concept map. But first go under **mapping** to **new concept** and type your name into this box. You have all the functions under **mapping** including "go back" to your essay or reading texts. Also you can use the little hand in the little picture to scroll around the map. If you want to make more essay concept maps, use the right arrow key. You can PRINT CARD under FILE when you are ready to make a hard copy.



✓

Relational statements are required.

L-4



Good structure
But no Physics concepts

SCIENTIFIC LITERACY DEVELOPMENT PLAN. L-5

<u>SENTENCE STRUCTURE</u> This is arranged according to the function of words such, as nouns, adjectives etc.

<u>NOUNS</u>

A noun is the name of a person place or thing or idea. The words in **bold** in the sentences below are functioning as **nouns**. Sometimes there are two words on a **noun**. This is called a **compound noun**:

In **sound**, the **disturbance** which progresses from one **point** in a **medium** to another, without **transport** of **matter**, is termed a **wave motion**.

You write down the **nouns** in the following(9):

This implies that energy must be continually flowing out of the source and through the medium. Thus there is a transfer of energy without a transfer of matter and this is another characteristic of wave motion.

ADJECTIVES

An adjective is a word that modifies a noun. In other words it tells you more about the noun. For example in the following sentence the adjectives in bold modify the nouns next to them:

When a **sustained periodic** force acts on a body, it is set in what is termed a **forced** vibration; The period of the **forced** vibration is that of the **periodic driving** force. A **feeble** sound can be made into a **strong** sound if the **natural** frequency of a box or **enclosed** air space is equal to the frequency of the sound.

You write down the adjectives (7):

Whenever the driving force acting on a system coincides with that of a free vibration of that system then the resulting forced vibrations are of large amplitude. This special case of a forced vibrations whose period is that which is natural to the body is termed resonance

ADVERBS

An adverb is a word that modifies a verb, another adverb or an adjective. For example:

Particles which are moving **simultaneously** in the same direction, **up** and **down** for transverse waves and **side to side** for longitudinal waves, are **in phase.**

Now you write down the adverbs in the following (5):

Similarly particles which are all instantaneously at rest and have the same maximum displacement are in phase. It is customary to denote wavelength by the symbol λ.

VERBS

Verbs are the action words between the nouns, adjectives, pronouns adverbs etc in a sentence. They usually doing or being as indicated in the following:

Another fact **brought** out by research on the sensitivity of the ear **is** that once the threshold frequency **is exceeded**, then increases in intensity **produce** increased loudness. The constituent tones into which a given note **can** be analysed **are** partial tones.

Now you write down the verbs in the following (4):

The term loudness refers to the degree of sensation produced by the sound waves when they impinge on the ear; loudness is not therefore a purely physical phenomenon but depends partly on the sensitiveness of the ear under particular conditions.

SENTENCE STRUCTURE

In English, the simple sentence consists of SUBJECT, VERB, OBJECT, where the subject and object are nouns or groups of nouns, adjectives and adverbs. A PHRASE can be in the SUBJECT or the OBJECT For example:

Energy	from the transmitter	causes	vibratory motions	of the electrons
SUBJECT	PHRASE	VERB	OBJECT	PHRASE

High pitch sounds	damage	the fibres	in the inner ear
SUBJECT	VERB	OBJECT	PHRASE

A CLAUSE is like a sentence within a sentence. It often has its own subject, verb object and is joined to the main sentence by a CONNECTIVE such as "when", "which", "because" etc.

You select the subject, verb object in these sentences and clauses:

When pressure is exerted by the stirrup on the oval membrane of the inner ear, the pressure on the cochlea liquid is relieved by an outward bulging movement of the membrane across the round window

Sentences always begin with a capital letter and end with a full stop. Phrases and clauses are separated within the sentence by commas. For example:

In general a sound can be classified as either a noise or a musical note. Some sounds however, are a combination of noise and a musical note. For example, when filling a kettle, the splash of water is heard as well as the rising pitch of the sound.

Rewrite the following in sentences phrases and clauses:

For wind instruments the principal vibration is in the air column however two classes can be distinguished one type is exemplified by the pipe organ in which the various notes are obtained by means of a graduated series of pipes of suitable lengths similar to a piano each pipe is separately excited

Paragraph Writing

L6

There are FOUR types of paragraphs that are used in science.
1. Definition
2. Comparison & contrast
3. Sequence & consequence
4. Description

1. Definition

A definition has four parts :

	Example #1	Example #2
1. The item	Fish are	Heating elements are
2. class in which it belongs (higher on the concept map)	marine animals	conductors
3. distinguishing features changing	with gills & fins	which, due to resistance
4. uses or operation in	to live & move in water	produce thermal energy

2. Comparison & contrast

Connectives used here include :

similar to	whereas ....
resembles	unlike ....
in the same way	in contrast to ....
just as	differs from ....
in common with	distinctive from ....
both	although ....

Example:

Series & parallel circuits **both** consist of electrical components or resistors forming a closed circuit with a power supply. In series circuits, the P.D. (e.m.f.) across the power supply is equal to the sum of the P.Ds across each of the resistors unlike parallel circuits where it is equal to the P.D. of each.

3. Sequence & consequence

Consequence : a result of an action
Sequence : events following each other not necessarily caused by the first.

Consequence	**Sequence**
causes	to begin with ....
leads to	initially ....
gives rise to	after this ....
brings about	at the same time ....
is caused by	during ....
is due to	secondly ....
is the result of	eventually ....
because	subsequently ....
is the effct of	finally ....

Lower concepts in a concept map are the consequences or a sequence of the higher ones.

Example

A battery causes a potential difference in a circuit because of stored energy. Eventually the battery energy runs out and no further current can be drawn.

4. Description

F. for, further
A. and, again, added to
N. not, nor, never
B. because, therefore
O. or, alternatively
Y. yet, nevertheless
S. so, sometimes

Reading texts

L-7

The next few cards have sections of text from modern day stories about the sound. You can extend your concept map by using some of these **concepts** and *relational statements*.

You should now have some idea about your essay topic. You can start building your concepts in the **essay concept map.** As you will need a bigger space to do this, you will now use a **essay concept map.** This is accessed at the bottom of each reading card and it will take you to a new card which you can make bigger for yourself by scrolling (explained later).

When you want to come back to the reading texts, then use the **go back** option in the menu **mapping** .

GO ON TO THE NEXT CARD

click here to go back | essay concept map | click here to continue

Here is a text that has the **concepts** in bold and the relational statements in the text.

Select some concepts and transfer them to your essay concept map by clicking on them.

Go to the next card for another text.

If you do not want to use all the reading texts go to card 30.

The bionic ear

Australia's pioneering bionic ear is called trhe '**cochlear implant**' and is the work of Professor Graeme Clark of the Royal Victorian Eye and Ear Hospital. The procedure is as follows:

1. A hole is drilled through the skull behind the ear
2. An electronic receiver is placed in the inner ear abou 50mm inside the skull
3. Sounds transmitted by a microphone behind the ear are converted by the speech processor into electric impulses in a coil
4. The coil converts the impulses into radio waves and transmits them to the radio receiver
5. The implant stimulates **inner ear nerves** which signal a range of different tones to the brain.

There are two types of hearing impaired, the **pre-lingual deaf** (born deaf) and the **post-lingual deaf** (gradually lost their hearing). The procedure assists the post-lingual people the most.

(The Weekend Australian Sep 5-6, 1987)

click here to go back | essay concept map | click here to continue

L-7 22

Now from this text, you can read about the natural levels of ionising radiation.

Notice that all new concepts are in bold print.

Begin selecting these concepts and *relational statements* and put them onto your scrolling concept map.

Now click over to the next text.

If you do not want to use all the reading texts go to card 30.

Bagpipes

High level noise from bagpipes could cause permanent **hearing loss** according to Dr. Stephen Brittain, a neurologist.

Indoor and outdoor levels at a player's left ear had reached **105 decibels**. Safety exposure maximums were set at 105 dB fro one hour or 115 dB fro 15 minutes. Constant practice might mean thay pipers would exceed these limits.

Good foam ear plugs could sharply cut noise levels. Dr. Brttiain who has been playing the pipes for about three years has started wearing ear plugs. His ear plugs reduced the sound level by about 25 dB and did not interfere with his hearing and evaluating his own playing, he said.

(The Courier Mail, 1987)

click here to go back | essay concept map | click here to continue

---

24

Here is another text for you to read and from which you may get further ideas for your scrolling concept map.

This may be a topic that you might like to write about either for sports safety of from a medical point of view. The text comes from "Medical Physics" (Cameron)

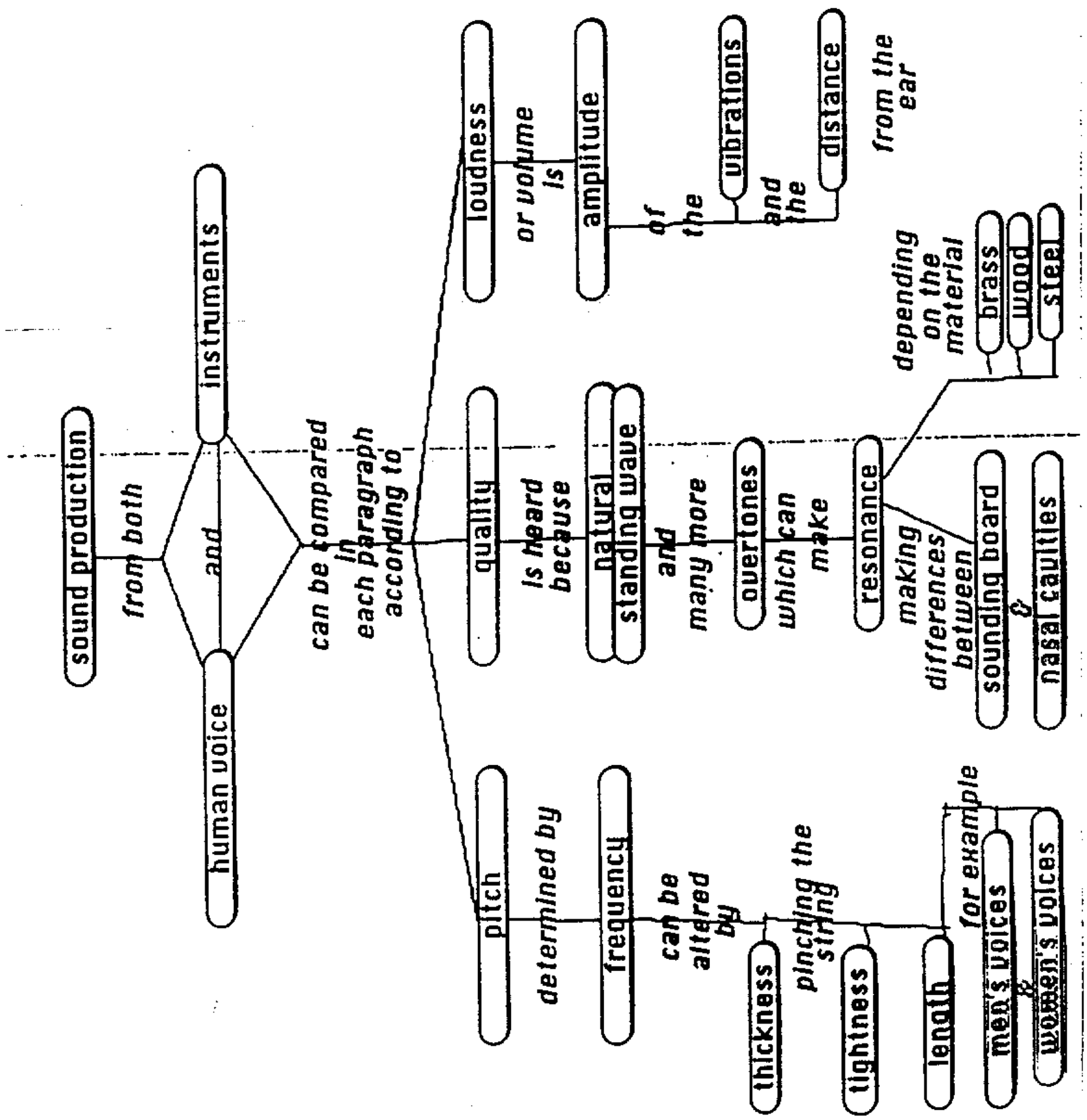
Go back to your scrolling concept map and add to it.

Stethoscope

Perhaps no symbol is more associated with the physician than the **stethoscope** hanging around her neck or protruding from his pocket. This simple 'hearing aid' permits a physician or nurse to listen to sounds made inside the body, primarily in the heart and lungs. The act of listening to these sounds with a stethoscope is called **mediate auscultation**. Sounds form the chest region can be useful in the diagnosis of disease.

R.T.H.Laenec invented the stethoscope in 1818 usinbg a hollow wood cylinder. The instrument today has earpiece, tubing, open bell which has a valve for closing and a diaphragm. The diaphragm has a natural resonant frequency at which it most effectively transmits sounds. The factors controlling the **resonant frequency** are similar to those controlling the resonant frequency of a stretched vibrating wire. It is possible to enhance the sound range of interest by changing the bell size and varying the pressure of the bell against the skin and hence the skin tension. Heart sounds are generally of low frequency while lungs emit a higher frequency..

click here to go back | essay concept map | click here to continu


sound production
from both
human voice
and
instruments
can be compared in each paragraph according to
pitch
determined by
frequency
can be altered by
thickness
pinching the string
tightness
length
for example
men's voices
&
women's voices
quality
is heard because
natural
standing wave
and many more
overtones
which can make
resonance
making differences between
sounding board
&
nasal cavities
depending on the material
brass
wood
steel
loudness
or volume is
amplitude
of the
vibrations
and the
distance
from the ear

Type your title here:SOUND

SOUND PRODUCTION

The sounds produced by stringed instruments can be compared to how the the human voice behaves in varying ways. Each sound that is ever produced is distinguished by three characteristics. These are pitch, loudness and quality and they all contribute to the sounds we hear in different ways.

The pitch of a note is an indication of it's position on the musical scale and is determined by it's frequency. The frequency is the number of compressions produced by a vibrating object each second. The more rapidly an object vibrates, the higher the frequency will be. High pitched sounds have higher frequencies than low pitched sounds.

In stringed instruments there are three contributing factors which have effect on the pitch of a sound. These are the thickness, tightness andlength of the strings. On a guitar, for example, all six strings are the same length but can be altered by pinching the strings on the fret board. This means the length of the wire that is free to vibrate is shorter, increasing the pitch of the note. Similarly, the shorter strings on a harp produce high pithed notes whereas the long strings play low pitched notes.

Differences in the sounds produced by musical instruments are often described in terms of their quality or timbre. Almost every musical sound consists of a combination of the actual note sounded and a number of higher notes related to it. The actual note played is the fundamental and the higher tones are overtones of the fundamental.

When a note is produced by a violin string, the string vibrates as a whole and produces the fundamental. But the string also vibrates in separate sections at the same time. Each of these vibrations produce an overtone of a higher frequency and pitch than the fundamental. The number and strength of the overtones help determine the characteristic sound quality of a musical instrument. Differing amplitudes in the overtones produced, create different sounds between stringed instruments. The overtone amplitude is related to the type of material the instrument is made from (brass, wood, steel e.t.c.) , and it's shape.

Resonance has an effect on the quality of sound as well. Resonance is created when a particular tone causes a nearby object to buzz or vibrate. This reveals that the object has a natural standing wave frequency in common with the tone. This, in the construction of musical instruments, adds richness and volume to the sound. The piano, for example, has a surrounding board that resonates with the tones produced by the strings, increasing the quality.

The loudness of a note is determined by the amplitude of the vibrations in the sound wave reaching the ear. This depends on the amplitude of the vibration and also on it's didtance from the ear.

The human voice can be compared to a string instrument, as in many ways it produces sound similarly. The vocal cords are the main sound producers in humans and they are like the strings on instruments. These two small folds of tissue stretch across the larynx (voice box). When we breathe, we relax our vocal cords so that they form a V shape opening that lets air through. When we speak, we pull the vocal cords by the attatched muscles, narrowing the opening. Just like a stringed instrument, the sound of our voice can be varied. The more tightly the vocal cords are stretched, the higher the sounds produced. The more relaxed the cords, the lower the sounds. The pitch of the voice is determined by the size of the larynx. Women's voices are usually pitched higher than men's because their vocal cords are shorter. The tongue, lips and teeth also help shape the sound of the voice. In addition, the nasal cavity gives resonance and colour to the voice.

From all these various aspects of sound production it is easy to compare the human voice to stringed instruments. Although different in physical structure and appearence, the two share similar qualities and work in the same theoretical way.

WRITING TASK

You will now have had two classroom lessons in Elementary Sentence Construction and Paragraph Writing. You are now ready to do your writing task. The decisions we will make are:

1. genre selection
2. language register selection
3. concept selection.

HCP program will give you three examples of selecting and doing the writing task.

Just click over and read ahead.

31

1. GENRE SELECTION

1. Recount a story using concepts from the concept map.

2. Write a report, say about a laboratory practical. Use the concept map to help with your conclusion.

3. You can write the procedure for an experiment to test the relationship between concepts

4. You can give an explanation of your topic. This is normally done with concepts from each level in your concept map. Each level is a paragraph eg. impact.

The first example

5. An exposition is where you take one section of theory, say the dangers of Bungie jumping. Develop your argument through the levels of the concept map.

The second example

6. A discussion genre is where you take two interpretations of a theory and compare them.

32

2. Selection of LANGUAGE REGISTER

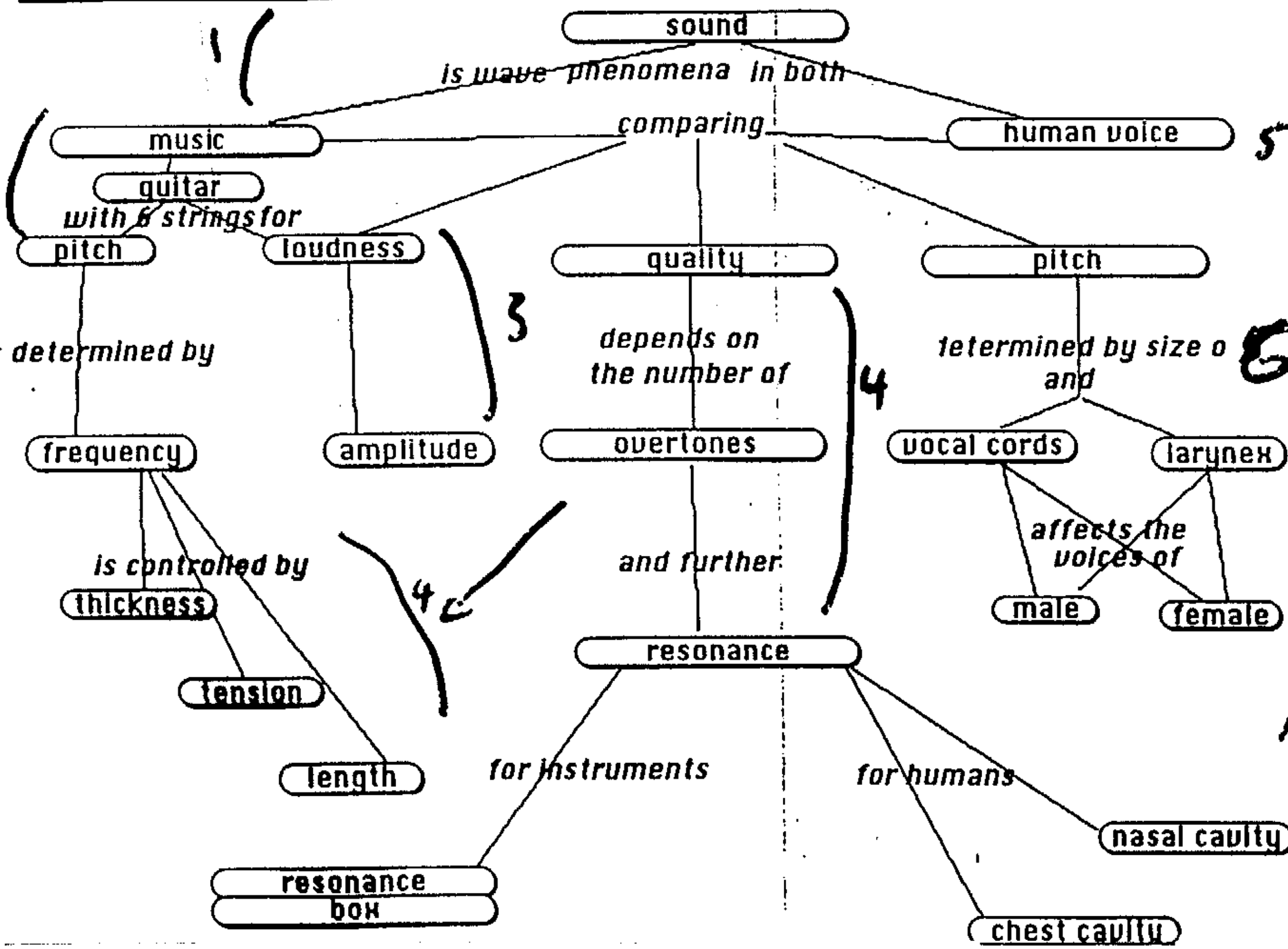
	AUDIENCE	STYLE	TENSE	PERSON
Recount	other students	technical (passive)	simple present	first
Report	teacher examiner	formal	continuous present	second
Procedure	newspaper	(active)	simple past	third
Explanation	younger students	informal (active)	past perfect	
Exposition	for a text book	slang (never!)	future	
Discussion				

This is what has been chosen in HCP: Explanation genre, teacher audience, informal style, simple present tense verbs, and first person pronouns. Click over and have a read.

click here to go back

click here to continue

This is your essay concept map. But first go under mapping to new concept and type your name into this box. You have all the functions under mapping including "go back" to your essay or reading texts. Also you can use the little hand in the little picture to scroll around the map. If you want to make more essay concept maps, use the right arrow key. You can PRINT CARD under FILE when you are ready to make a hard copy.



FIRST ESSAY

Type your name here:[redacted]

Type your title here:Sound

Sound is what, we humans, here through our ears all the time, and it travels from it's sourse to the observer in the form of waves. One sound wave phenonemon is music. All musical instruments produce sound and most instruments opperate in the same way as with the human voice. Sound waves are produced when an object vibrates rapidly in the air. This object may be the string of a guitar or the vocal cords in our throat. Musical instruments and the larynx both produce sound, but different instruments and people produce varies sounds, which all inter-relate to the pitch, loudness and quality.

The production of sound from musical instruments relies on the generation of a standing wave. For stringed instruments the standing wave occurs in a string. A guitar has six strings stretched over a resonance box; whose tension can be altered by using tuning pegs. The pitch of a musical note corresponds to the frequency , therefore the higher the frequency the higher th pitch. The tension of a string controls the frequency at which it vibrates and therefore the pitch of the sound it makes. An increase in the tension of the string increases its frequency, which in turn makes the string vibrate faster, resulting in a shorter wavelength and a higher pitch. Each string has a differen mass per unit length and as the thickness of a string increases the frequency decreases and this time the pitch is low. Another factor affecting frequeny is the length of the string. Even though the strings are of equal lengths, different notes can be played by altering the the length of each strings, by stopping it with the fingers.

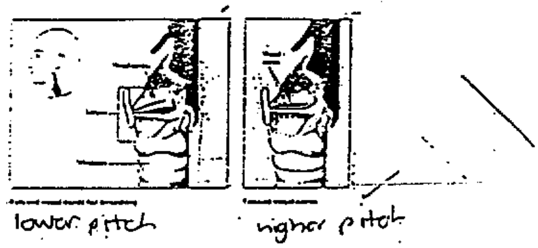
The loudness of a note is determined by the amplitude of vibrations i the sound wave reaching the ear. By plucking a guitar string harder, this produces larger vibrations and these produce waves with greater amplitude, which are heard as being louder.

Resonance plays an important part in all musical instruments by increasing the loudness of the sound they produce, because another body is caused to vibrate with the source.

The quality of an instrument distinguishes the difference between the same note heard on a trombone and on a guitar . Ofcource the same notes sound different because they are two different instruments and their musicl notes have different qualities. Musical sounds are composed of overtones. The note o lowest frequency is called the fundamental frequency. It is a variety of overtones that give a musical note its quality and characteristic.

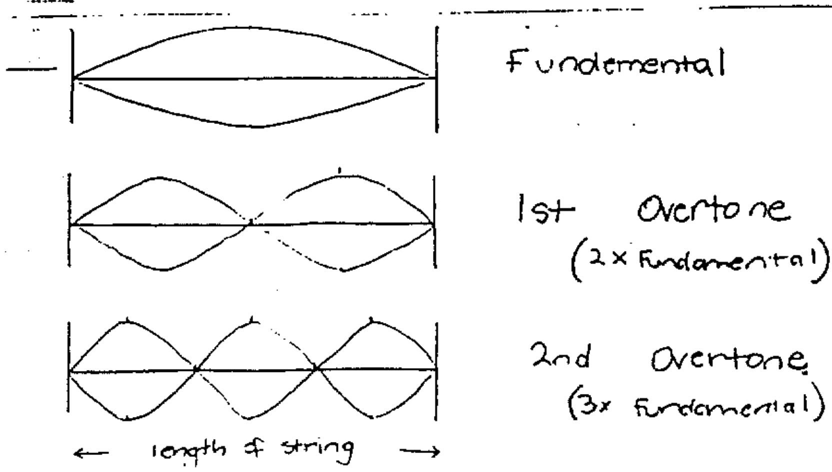
When a sting of a guitar is plucked, all the possible overtones are created, but because each has a different amplitude, the overtones present affect the quality. An instrument with its sounds in the higher overtones is said to have a high quality and vice versa.

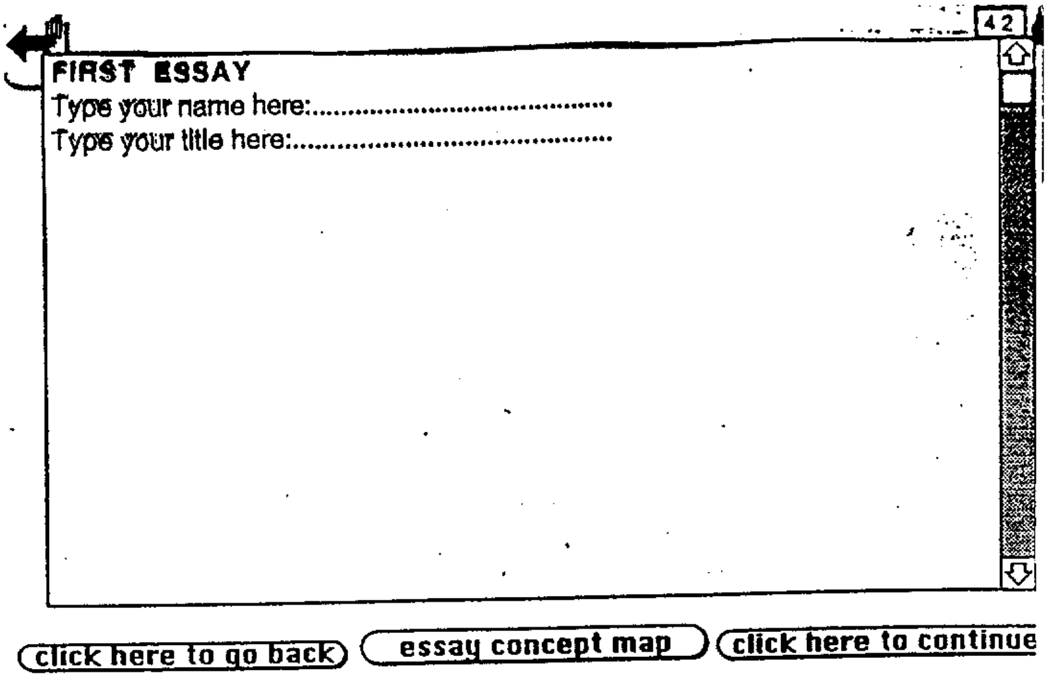
The human voice is an example of sound produced by air colums vibrated by membranes. The vocal cords are located on each side of the larynx(voice box) and as we breathe air from the lungs through the larynx, the air vibrates the vocl cords and sound results. Similiar to a guitar, by changing the muscular tension of the cords, sounds of different pitch are produced. The more tightly stretched they are, the higher the sound produced and vice versa.

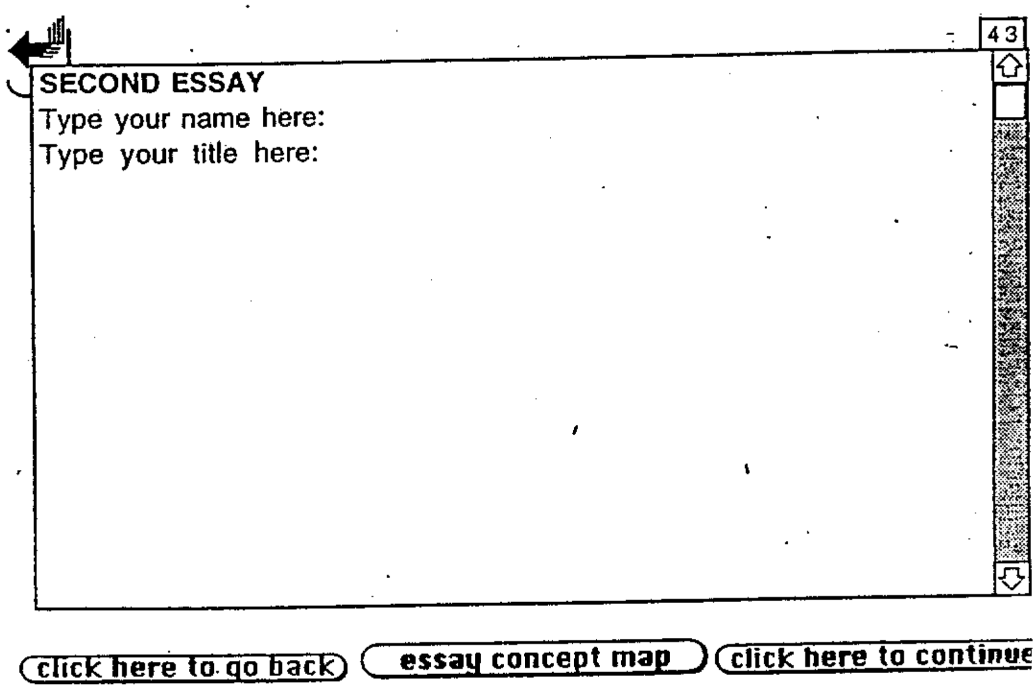


The pitch of the voice is also determined by the size of the larynx. The reason woman' s voices are usually pitched higher compared to men' s is because their vocal cords are shorter. While men' s voices are low pitched since their vocal cords are longer.In the case of the human voice, the quality is determined by the shape of the vocal tract. The nasal cavity and the chest cavity gives resonace to the voice and that is why a person' s voice changes when they have a cold.

There are many similarities between the human voice and a stringed instrument. The pitch is affected by similar factors like length, tension and thickness.




42
FIRST ESSAY
Type your name here:..
Type your title here:..
click here to go back
essay concept map
click here to continue


43
SECOND ESSAY
Type your name here:
Type your title here:
click here to go back
essay concept map
click here to continue

44

THIRD ESSAY
Type your name here:
Type your title here:

(click here to go back) (essay concept map) (click here to continue)

45

YOU HAVE MADE IT TO THE TOP OF THE MOUNTAIN !

When you have finished your essay you can see your teacher about using "cut and paste" to transfer it to a word processing document for "spell check" and "grammar check".

This is the end of this method of learning how to write essays using HCP. You should be able to do them on your own now.

Keep the steps in mind:
1. Choose the genre.
2. Select a language register: (intended audience, style, verb tense, pronoun)
3. Select your concepts and relational statements from a concept map.

We hope you enjoyed this form of ***mountaineering!*** Now that you are at the top of the mountain of knowledge about Year 11 dynamics you can look around and see how to write many other types of essays. ***Happy writing!***

Whenever you want to quit out of the program, go under FILE down to QUIT.

(click here to go back) (Click here to start again)

Appendix 5.3
Scoring scheme for concept mapping

This scoring scheme takes account of the number of concepts used, hierarchical levels, links between concept names and relational statements.

SCORING SCHEME FOR CONCEPT MAPPING

CRITERIA	DEFINITION	SCORING
Concepts	A single object, event or idea that stands alone and can be represented by a word(s) or symbol which can be linked to other concepts.	Count the number of concepts used. Score 1 point for each concept.
Hierarchy	The hierarchy is the structure that has general, abstract, inclusive concepts at the top; followed by levels of principles, laws and conventions; calculated and measured concepts; and observed phenomena at the bottom.	Count the number of definite levels in the structure. Score 2 points for each level.
Linking	Concepts can be linked with link lines. by being subsumed or grouped in clusters.	Count the number of lines drawn. Score 1 point for each link.
Branching Points	Branching is the differentiation of a concept into two or more subsumed concepts. The point of differentiation is called the nodal point. It also forms a cluster, when used ABOVE the concept.	Count the number of nodal points. Score 1 for the nodal point and add 1 for each further branch.
Relational Statements	They are the phrases written on the link lines that join the concepts in a sentencs. The sentences are to be read UPWARDS or DOWNWARDS. They may be simple language connectives or technical joining phrases.	Score 1 point for each seperate relational statement and 2 point for technical joining phrases.

Appendix 5.3

Appendix 5.4
Computer script of the HCP modules

This is some of the script of the "Magnetics" module. There are seven other similar scripts in physics modules, two in chemistry and one in biology.

Pages 40 to 50 are the visible screen texts presented to students in the HCP modules.
Page 51 is the "Commence" button script.
Pages 52 to 54 are the scripts of various buttons for navigating through the stacks.
Pages 55 to 63 are the scripts of the first stack and cards that build the concepts and relational statements into the menus for use by students.
Page 64 to 65 are the scripts that give access to one of the definitions in hidden fields and to the selection of concepts from the contextual readings.
Pages 66 to 70 are the scripts of the stack and cards that enable concept mapping to be performed.
Pages 71 to 79 are the scripts of the spelling checker.
Pages 80 to 85 are the scripts of the grammar checker. (The word 'grammer' is a code variable and is not visible to the user.)
Pages 86 to 88 are the scripts for the document statistics counter.

There are other scripts to hidden buttons and fields, for example the field coded "correct" is a topic specific thesaurus which is activated when the student chooses the spelling checker and an unfamiliar word is encountered.

Click on this background button whenever you want to come back to this card.

1

To commence the program
CLICK HERE **Begin here**

To skip over to the reading
CLICK HERE **Reading texts**

To skip over to concept map
CLICK HERE **essay concept map**

To skip over to the writing
CLICK HERE **Writing task**

To skip over to the typing
CLICK HERE **essay typing**

Whenever you want to quit out of the program, go under FILE down to QUIT.

2

HCP Writing In Science

Hello Year 11 Students.
This program is designed to help you to read and write better in this particular topic of Physics **"magnetics"**. You will mainly be using this computer program but there will be some supporting classroom lessons. At the end of the program (12 lessons) you should have two well written essays that you can file away for your own use later.

This computer program is written in HyperCard hence the name HCP meaning "HyperCard Physics". Each screen is called a card and you click over with one click of the mouse button in the appropriate button.

CLICK OVER TO THE NEXT CARD NOW

Click here to continue

3

DECISIONS I

Before you start writing about a topic you have to make three decisions-

1. In what **genre** do you wish to write
2. In what **language register** do you wish to write
3. What **concepts** will you use

The following cards will help you to make these decisions

NOW CLICK OVER TO THE NEXT CARD

Whenever you want to quit out of the program, go under FILE down to QUIT.

Click here to go back **Click here to continue**

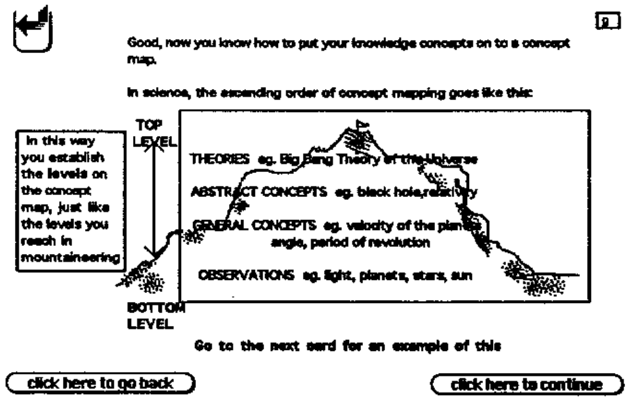
4

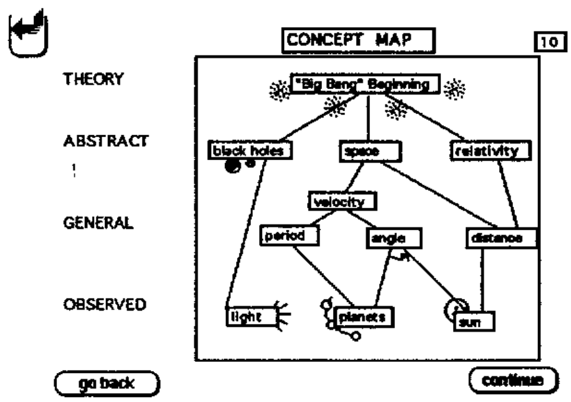
FIRST STEP: SELECTING THE GENRE REQUIRED

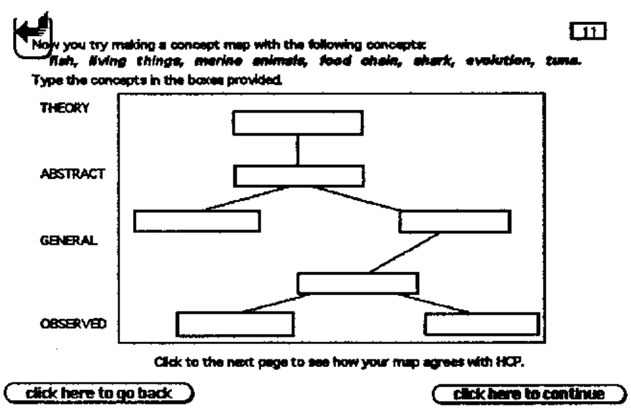
1. **Recount** is a story about a person or an activity. Use a "time-line". **time-line**
2. A **report**, say about a laboratory practical or some other investigation. Use an "outliner" **outliner**
3. You can write the **procedure** for an experiment or investigation. Use a "flow chart". **flow-chart**
4. You can give an **explanation** of your topic. Use a "concept map". **concept map**
5. An **exposition** is a persuasive argument where you take one section of theory. Use a "concept map". **concept map**
6. A **discussion** argument is where you take two interpretations of a theory to compare and contrast them. Use a "concept map". **concept map**

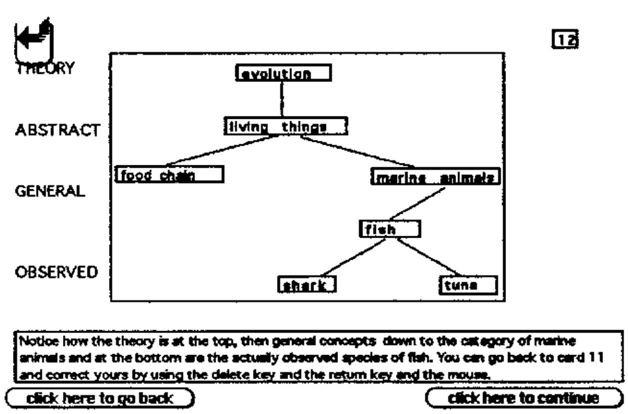
CLICK ON THE GENRE YOU SELECT

Click here to go back **Click here to continue**


9
Good, now you know how to put your knowledge concepts on to a concept map.
In science, the ascending order of concept mapping goes like this:
In this way you establish the levels on the concept map, just like the levels you reach in mountaineering
TOP LEVEL
THEORIES eg. Big Bang Theory of the Universe
ABSTRACT CONCEPTS eg. black hole,relativity
GENERAL CONCEPTS eg. velocity of the planets angle, period of revolution
OBSERVATIONS eg. light, planets, stars, sun
BOTTOM LEVEL
Go to the next card for an example of this
click here to go back
click here to continue


CONCEPT MAP
10
THEORY
ABSTRACT
GENERAL
OBSERVED
"Big Bang" Beginning
black holes
space
relativity
velocity
period
angle
distance
light
planets
sun
go back
continue


11
Now you try making a concept map with the following concepts:
fish, living things, marine animals, food chain, shark, evolution, tuna.
Type the concepts in the boxes provided.
THEORY
ABSTRACT
GENERAL
OBSERVED
Click to the next page to see how your map agrees with HCP.
click here to go back
click here to continue


12
THEORY
ABSTRACT
GENERAL
OBSERVED
evolution
living things
food chain
marine animals
fish
shark
tuna
Notice how the theory is at the top, then general concepts down to the category of marine animals and at the bottom are the actually observed species of fish. You can go back to card 11 and correct yours by using the delete key and the return key and the mouse.
click here to go back
click here to continue

13

On your next card you will begin concept mapping your knowledge of **magnetics**. You will be presented with a list of concepts that you can arrange in your own way. Definitions of the concepts can be found by clicking onto the definition button • and holding the mouse button down. Try this.

north pole •
south pole •
iron filings •
magnetism •
attraction •
bar magnet •
repulsion •
EM wave theory •
electromagnet •
magnetic field •
induced current •

Now go on to the next card.

click here to go back | click here to continue

14

1. Open **Mapping** in the menu bar and drag the mouse down to **List of Concepts** and release the mouse button. This list will now appear in the menu bar.

2. Open **List of Concepts** and select a word.

3. Click on the concept and drag it (mouse down) to the place you want on the concept map and then release the mouse button.

4. Continue selecting concepts and place them on your concept map.

5. Now select line under **Mapping** in the menu bar and join up the concepts which are related.

click here to go back | definitions | click here to continue

15

Now you are ready to begin *naming the tracks*. Remember the way to go from level to level on the mountain was by tracks. On concept maps these are called *relational statements*. We will use *italic* typing for these.

They are phrases that connect two concepts. For example the relational statement between the concept **bar magnet, north pole** and **south pole** is:
--contains--, --with a--

It is drawn on the concept map as follows:

This is reading from TOP down to BOTTOM.

GO ON TO THE NEXT CARD

click here to go back | definitions | click here to continue

16

Mountaineers would find a map of the tracks up to Mt.Compass very handy.They would know when they had reached **Cliff Point** or *Valley View* .They would find it even more helpful to speak to others who had been there before. It is the same with the knowledge mountain. The *relational statements* tell the learner to move from one level of knowledge to the next.

The *relational statements* between concept levels are usually verbs or connectives or Physics rules. Here are some examples:

VERB PHRASES	CONNECTIVES	RULES
used in---	*F. for, further*	*vel = f x L*
is an example of--	*A. and, again, added to,*	*vel = d x t*
contains---	*N. not, nor, never*	*using beats*
belongs to---	*B. because, therefore*	*changing pitch*
is measured by---	*O. or, alternatively*	
is the property of-	*Y. yet, nevertheless,*	
causes---	*S. so, sometimes*	

GO ON TO THE NEXT CARD

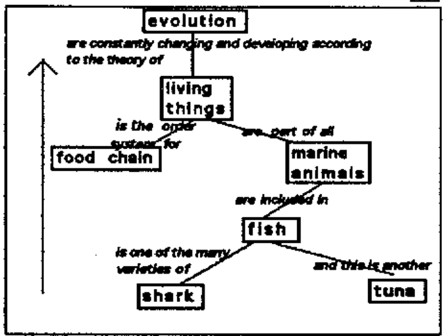
click here to go back | definitions | click here to continue

17

Here is an example of the use of *relational statements* in the fish concept map. Read the map from the BOTTOM upwards.

Can you extend this map using other concepts and making up your own *relational statements?*

Click over to the next card when you are ready.



click here to go back | GO ON TO THE NEXT CARD | click here to continue

18

1. Now using the List of Concepts build another 'magnetics' concept map. Place the concepts in the correct height order. You can make changes to the way you did it before.

2. Select line and draw in the connecting lines again.

3. Now open mapping again and select **relational statements.**

4. Select one *relational statement* for every connecting line. You can alter the words of the relational statement to make them fit the concepts better if you wish.

5. Drag the one you select to each connecting line.

6. You can erase if you wish.

click here to go back | definitions | click here to continue

click here to go back | definitions | click here to continue | 19

Now you can make a concept map by making up your own concepts. Select **mapping** and select **new concept** and then type your own concept into the dialog box, you can then move this concept around. Similarly you can make up your own relational statements by selecting **new relationship** from the **mapping** menu.

20

Reading texts

The next few cards have sections of text from modern day stories about the **magnetics**. You can extend your concept map by using some of these **concepts** and *relational statements.*

You should now have some idea about your essay topic. You can start building your concepts in the **essay concept map**. As you will need a bigger space to do this, you will now use a **essay concept map**. This is accessed at the bottom of each reading card and it will take you to a new card which you can make bigger for yourself by scrolling (explained later).

When you want to come back to the reading texts, then use the **go back** option in the menu **mapping** .

GO ON TO THE NEXT CARD

click here to go back | essay concept map | click here to continue

21

Here is a text that has the concepts in bold and the relational statements in the text.

Select some concepts and transfer them to your scrolling concept map by clicking on them.

Go to the next card for another text.

If you do not want to use all the reading texts go to card30.

IT'S FULL SPEED AHEAD FOR THE "LOOK! NO WHEELS" RAILWAY

The world's first commercial "Look! No wheels" railway comes into service in Birmingham in a few weeks (18-9-84).

Suspended on a **magnetic field** about 2cm above the track, the train cars will shuttle between the airport terminal, the national exhibition centre, and its nearby railway station.

The Birmingham Maglev (from **magnetic levitation**) is less than a kilometre long and the cars will have a top speed of about 45 km per hour.

The train cars will sit on the track when at rest. When they need to move off, pairs of **electromagnets** at each corner reaching down to the underside of the track will lift the train car by **magnetic attraction**. Propulsion and breaking is by **linear induction motors**, an arrangement of **magnetic coils** in the car and a strip of metal down the centre of the track.(New Scientist)

click here to go back | essay concept map | click here to continue

22

Now from this text, you can read about the natural levels of ionising radiation.

Notice that *all* new concepts are in bold print,

Begin selecting these concepts and *relational statements* and put them onto your scrolling concept map.

Now click over to the next text.

If you do not want to use all the reading texts go to card 30.

OUTER SPACE TUNING INTO THE UNIVERSE

Outer Space *is full of* **electromagnetic fields**.The twinkling **light** *we see* from stars on a clear night *is* just one *example*—a form of electromagnetic radiation which *has a* **frequency** *within* our **visible range**.

Stars also *give out* **electromagnetic radiation** with shorter wavelengths.But we cannot see it. At longer wavelengths, scientists on earth *can monitor* **radio waves** coming from space, even remote galaxies. They *can tune* into the Universe in the form of the famous **cosmic microwave background radiation** *left over* from the Big Bang itself. By monitoring radio waves from outer space, astronomers *can pinpoint* objects immense distances away. Other forms of electromagnetic radiation from space, such as **microwaves**, **X-rays** and **gamma-rays**, also give us valuable clues *about the* origin and nature of the Universe.

click here to go back | essay concept map | click here to continue

23

Here is another text from which you can get further ideas for developing your concept map.

Concepts are in **bold** while the *connectives* are in *italics*. They can be used as you **relational statement** on your concept map.

MAGNETIC RESONANCE IMAGING (MRI)

Magnetic resonance imaging is a scanner that *consists of* an **electromagnet** supercooled with **liquid helium**. *This allows* for a very strong **magnetic field** to be formed. A patient is then put inthe magnetic field for a few micro seconds and the **spinning protons** (hydrogen nuclei) in the body line up their spins in this magnetic field. How quickly the protons take to line up, *is called* **resonance**, can be measured.

These measurement are fed into a computer and an **image** *is made* on a TV monitor of the sections of the persons body that are being scanned. MRI has the advantage over x-rays in that the person *does not* have **ionising radiation**. MRI is used for the detection of cancer and other abnormalities.

click here to go back | essay concept map | click here to continue

24

Here is another text for you to read and from which you may get further ideas for your essay concept map.

This may be a topic that you might like to write about.

Go back to your essay concept map and add to it.

THREE DIMENSIONAL MAGNETIC FIELD IN A BOTTLE

Put about 25 g of coarse **iron fillings** in a 250 ml gas bottle. Cut a 16mm hole in the cork at the top of the bottle for a test tube to be lowered into the bottle. Drop a **magnet** into the test tube. (Put a small piece of plastic tubing at the bottom of the test tube to absorb the impact of the magnet).

Now shake it up and down gently and observe the three dimensional nature of the **magnetic field**. It seems to be in **lines**. The density of these lines (flux density) is called the magnetic field sterngth

The unit of **magnetic field strength** is Tesla(T). This magnet would be about 0.5 T. The Earth has a magnetic field strength of about 0.00005 T. A superconductor could have a magnetic field strength of 20 or 30 T. Read your textbook for further information.

click here to go back | essay concept map | click here to continue

25

MAGNETIC FIELDS OF SUPERCONDUCTORS

At very low temperatures (-273°C = 0°K) up to about -180°C (about 100°K) some certain materials become superconducting materials, that means they can carry very large currents without heating up. This is because there is no electrical resistance. They also become surrounded by very strong magnetic fields, which can cause levitation of other objects. (Alex Muller and Georg Bednorz won the Physics Nobel Prize in 1987 for their discoveries in 1986).

It used only happen at temperatures very close to 0°K. Then Paul Chu and helpers at Houston University produced superconductivity at 90 to 100°K and now they have found a new record high at 225°K, although it is unstable.

The new material *is called* ceramic (yytrium-barium-copper-oxides with substituted rare earth elements). An experiment in space to be carried out in 1992 and 1996 is called the High Temperature Superconducting Space Experiment.This *will lead to* better microchips for computers and communications systems and extremely high magnetic fields for electric power generation transport levitation systems, and better medical diagnostic equipment, for example in Magnetic Resonance Imaging.

click here to go back | essay concept map | click here to continue

26

JAPANESE USING OLD PRINCIPLE FOR FUTURISTIC SHIP

A supership capable of travelling at 100 knots (185 km per *hr*) on or beneath the waves but without a propellor, could be in operation by the end of ther century. It will *be propelled* by no moving parts but by still, silent electromagnet thrusters.

The power source is a futuristic application of classroom physics, specifically *Fleming's Left Hand Rule*, which states that a *magnetic field in the presence of* an electric current produces force. The ships would be propelled and steered by the forces created between the sea and banks of super-conducting electro magnets located in the hull.

A magnetic field in the sea water caused by passing a current between electrodes on the port (right) and starboard (left) sides, interact with those caused by the electromagnets. This *generates* a force through the length of the ship, which is thrust forward by the jet of water moving astern.

click here to go back | essay concept map | click here to continue

27

Continue building your concept map.

Your mountain of knowledge about magnetics must be quite large now with many tracks and levels. You do not have to use all the concepts.

Well done keep going!

UFO's

I spoke with Drs Svengenii Zhibizov, Victor Zhuravliev and Aleksei Dmitriev of the State University, each of whom was deeply involved in field research in a geomagnetic anomolies region. Dr Dmitriev told me about one of his own sightings which took place at night in 1976 during a field expedition on geomagnetic characteristics of the earth. Another member in his party took six consecutive photographs of the chevron-shaped lighted object. Although the photographer said he centred the light in the camera's view finder, after development the object's image was found to be displaced laterally about 30° arc for no apparent reason.

Others noted fluctuations in the local magnetic field when the object was hovering nearby, and no such variations were noted at another sensor site 140 km away. The variations lasted 14 minutes and the light was seen by nine witnesses. This case was never written up. (Earth Lights Up)

click here to go back | essay concept map | click here to continue

28

Magnetic Anomolies

It will be on maps of Wales (UK) that the magnetic anomolous regions of Wales exactly correspond to the areas of peak UFO incidence in that country. The perfect correlation is not so complete for England, hpwever, so the evidence suggests that while a disturbed magnetic environment seems to play some part in UFO manifestation it can only be a secondary factor. There must be more vital characteristics of fault regions as far as UFO appearance is concerned.

Rocks containing high concentrations of metallic sulphide minerals, or those containing ionised groundwater may display considerable conducting properties. These may be reasons to explain ther effectiveness of dowsing in geological surveys.

High metallic mineral concentrations produce complex magnetic and electric anomolies. Since these in turn can be attributed to geological events around tectonic plate margins we must consider plate movements as the prime overriding 'sign' in the Earth's crust.(UFO Report 1992)

click here to go back | essay concept map | click here to continue

29

Plastic Paper

Three Japanese companies have developed plastic "paper" that can be written on woth a magnet, erased again with a magnetic field and the companies claim, be reused again up to a 100, 000 times.

One of the companies Star Micronics will formally launch the paper next month (Nov. 1992). The first product using the paper is a plastic card called the Display Card.

The paper works on a similar principle to the liquid-crystal displays used in calculators and digital watches. Thre paper of the Display Crad is 0.2 mm thick and characters are written with a row of seven pins similar to those in an impact dot-matrix printer, except that they apply a magnetic field rather than hitting the paper. The company says that the printing is just as stable as the information written on the magnetic strip on a normal credit card. The image can be erased simply by passing a magnet over the paper.

The card will be launched together with a printer device that writes on the plastic paper and reads or writes on the magnetic strip at the same time. Its most likely first use will be in gaming machines. The card can be inserted into the machine to record the gambler's spending and winnings. Larger sheets can be used in office printers and fax [illegible]

click here to go back | essay concept map | click here to continue

30

WRITING TASK

You will now have had two classroom lessons in Elementary Sentence Construction and Paragraph Writing. You are now ready to do your writing task. The decisions we will make are:
1. genre selection
2. language register selection
3. concept selection.

HCP program will give you three examples of selecting and doing the writing task.

Just click over and read ahead.

click here to go back | essay concept map | click here to continue

31

1. GENRE SELECTION

1. Recount a story using concepts from the concept map.

2. Write a report, say about a laboratory practical. Use the concept map to help with your conclusion.

3. You can write the procedure for an experiment to test the relationship between concepts

4. You can give an explanation of your topic. This is normally done with concepts from each level in your concept map. Each level is a paragraph eg. impact. [The first example]

5. An exposition is where you take one section of theory, say the dangers of Bungie jumping. Develop your argument through the levels of the concept map. [The second example]

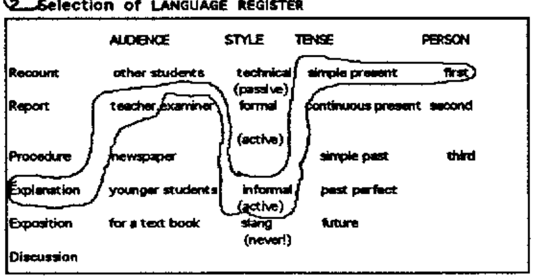
6. A discussion genre is where you take two interpretations of a theory and compare them.

The HCP program will now give you an example of an explanation essay. Click

click here to go back | click here to continue

32

2. Selection of LANGUAGE REGISTER



This is what has been chosen in HCP: Explanation genre, teacher audience, informal style, simple present tense verbs, and first person pronouns. Click over and have a read.

click here to go back | click here to continue

33

3.CONCEPT SELECTION

Select concepts from your scrolling concept map that best suits your topic. You should select only about four concepts from your concept map. These will be the themes of your four paragraphs. Decide on the order you will use: TOP to BOTTOM, or BOTTOM to TOP.

Pay attention to the relational statements between the concepts, because these will help you to link up the concepts and the paragraphs.

You can keep going back to the essay concept map while you are writing. Come back to the writing card by clicking on "go back" under the mapping menu.

You will be doing the essay by typing on the cards at the end of this HCP program.

CLICK OVER NOW FOR AN EXAMPLE

Click here to go back | essau concept map | Click here to continue

34

FIRST ESSAY

Question:
How do magnetic fields effect the way we live?

Answer:
I think the Earth's magnetic field has a number of effects on our lives. I will explain some of these using the theory and laws of magnetism to explain some everyday occurrences and some future applications.

The world I live in, is dominated by magnetism because of the magnetic field between the earth's north and south magnetic poles and because of fields made by current carrying conductors. The domain theory says that very small dipoles line up the same way to produce a magnetic field. The laws of Faraday, Lenz and Ampere allow us to make calculations about the strength of the earth's magnetic field and of a created or induced magnetic fields.

COMMENTS

Introduction.
It's a TOP to BOTTOM order .
First person Present tense

First paragraph.
Theory and laws.
Keeping first person and present tense.

click here to go back | essau concept map | click here to continue

35

The Earth's magnetic field protects us from some of the harmful cosmic rays because charged particles are spun around in circles when they come into a magnetic field. This is what we mean by the Van Allen Belts. The Earth's magnetic field also allows us to use a compass for finding our direction because the compass needle always lines up with the field lines pointing north.

An electromagnet works because the domains of the soft iron core line up lunder the influence of the electricity in the coil around it. Electromagnmets are used in radio speakers, cranes, electrical generators, and in our door bell at home.

Ampere's Law tells me about the force of attraction between two current carrying conductors or on a charged particle in a magnetic field. I know about the possibilty of train levitation because of this principle and also about charged particle accelerators.

Second paragraph.
An applicatioon of the first topic: earth's magnetic field.

Third paragraph.
Each paragraph begins with a high order concept and finishes with a practical example.

Fourth paragraph. There is a somethinf about the future, but the verbs are kept in present tense.

click here to go back | essay concept map | click here to continue

36

My car battery is recharged whenever I have the motor running because the coil of wires turning over inside a magnet causes a current to run back into the battery. My home electricity is also made this way at an SEC generator plant. These examples are applications of Faraday's Law which states that the voltage and hence current generated in a conductor (coil of wire) is proportional to the rate of change of the magnetic field.

Magnetic resonance imaging relies on the principle that the spinning protons of the cells in the body react to a strong magnetic field. My uncle's cancer was detected this way and he was able to be treated.

In conclusion, I understand many of the things I use in my every day life because of the domain theory and the laws of magnetism.

Fifth paragraph.
Emphasis on things in my life as demanded by the question.

Sixth paragraph.
A good personal example, but it must be short, because it's physics knowledge that the teacher is assessing.

Short conclusion restating the introduction.

click here to go back | esssay concept map | click here to continue

37

SECOND ESSAY

Here again is the same essay, but my selections will be different this time. I will choose to write an Exposition genre, for an intended audience of the Year 12 examiner,with formal (active) style, with simple past tense verbs and third person pronouns.

Question:
How do magnetic fields affect the way we live?

Answer:
Magnetic fields have a great bearing on the way that people live. Everyday applications can be best explained from the point of view of the domain theory of magnetism.

> Introduction.
> Notice third person and past tense.

The domain theory replaced the earlier molecular theory because it was realised that whole groups of molecules were already aligned into dipoles. The Laws of Oersted, Faraday, Ampere and Lenz are used in the calculations of field strength, direction, and force.

> Exposition must take one theory and show how logical it is.

click here to go back | esssay concept map | click here to continue

38

The domain theory explained the Earth's magnetic field by assuming that the nickel-iron core contained domains with aligned dipoles. This caused the north seeking and south seeking poles and the magnetic regions in space such as the Van Allen belts which were able to trap cosmic particles. Compass bearings in the Earth's magnetic field have been another advantage to humans.

> Second paragraph is about the Earth's magnetic field. It is TOP concepts down to BOTTOM.

Oersted discovered that electricity in a coil of wire would produce magnetism. This law has been applied in the manufacture of electromagnets for door bells radio speakers, and industrial cranes.

> Third paragraph. Remains impersonal.

The force of attraction or repulsion was calculated by Ampere. He explained the force that was created by the interference of magnetic fields. It was later utilised in the production of electrical dervices and in particle accelerators. The principle may be used in the development of train levitation.

> Fourth paragraph indicates a logical step in the performance of calculations for new applications

click here to go back | essay concept map | click here to continue

39

Faraday stated that the voltage generated by a moving conductor in a magnetic field was proportional to the rate of change of the field. This could be caused either by rapid turning of a coil as in a generator or by a fluctuating magnetic field as utilised in a transformer. The recharging of a car battery has been another application.

> The fifth paragraph has used the same concept order, past tense and third person.
> (No "my battery")

Medical resonance imaging was a new application of the domain theory of magnetism because it showed how the spinning protons of the body could be aligned in a strong magnetic field and then their position computerised to produce an image of the organ under investigation. Early detection of cancer has been a beneficial result.

> Sixth paragraph.
> You assume the examiner knows what MRI is. You would have to explain it for another audience.

It can be concluded that the understanding of the domain theory of magnetism has led to many everyday applications.

> Short conclusion , but the exposition of the domain theory is emphasised.

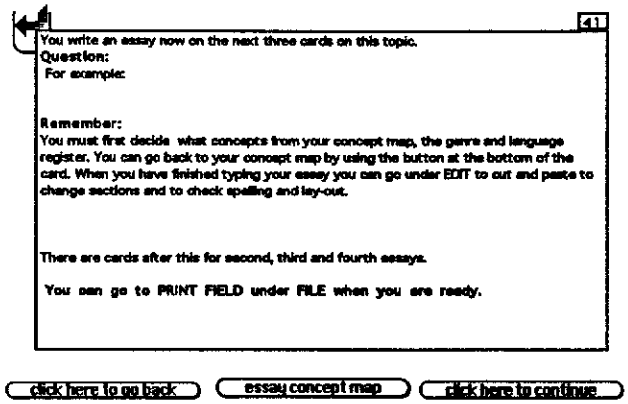
click here to go back | essay concept map | click here to continue

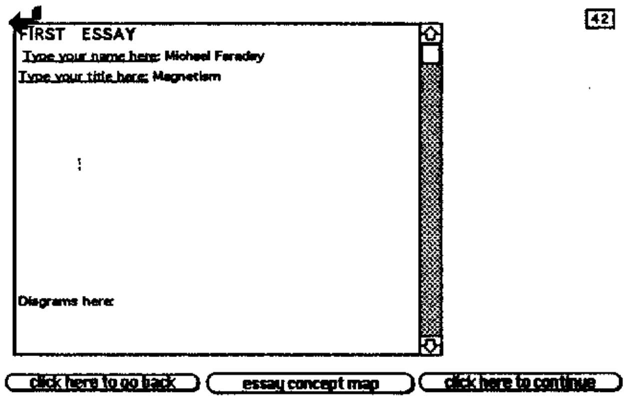
40

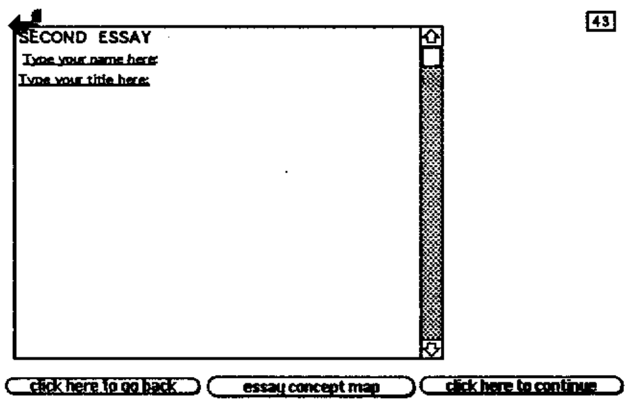
The essay will be marked according to the following criteria:

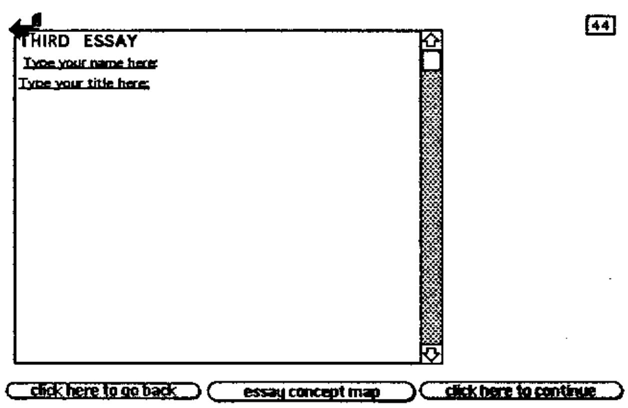
	Not adequate	Adequate	Grade
1. Foundational criteria:			
• legibility, layout and length	———		
• spelling, punctuation, grammar	———		
• sentence and paragraph construction	———		
• consistent language register	———	standard	
• fluent & coherent for the reader	———	to be met	
2. Multistructural criteria:			
• foundational criteria already met	———	C	
• range of relevant scientific concepts and/or applications to everyday life	———	C+	
• NEGATIVE: incorrect scientific concepts		C-	
3. Relational criteria:			
• logical development and use of language connectives between paragraphs	———	B	
• specific scientific relations such as equations, word analogues or mathematical expressions that show development and extension of concepts	———	[illegible]	

click here to go back | click here to continue


41
You write an essay now on the next three cards on this topic.
Question:
For example:
Remember:
You must first decide what concepts from your concept map, the genre and language register. You can go back to your concept map by using the button at the bottom of the card. When you have finished typing your essay you can go under EDIT to cut and paste to change sections and to check spelling and lay-out.
There are cards after this for second, third and fourth essays.
You can go to PRINT FIELD under FILE when you are ready.
click here to go back
essay concept map
click here to continue


42
FIRST ESSAY
Type your name here: Michael Faraday
Type your title here: Magnetism
Diagrams here:
click here to go back
essay concept map
click here to continue


43
SECOND ESSAY
Type your name here:
Type your title here:
click here to go back
essay concept map
click here to continue


44
THIRD ESSAY
Type your name here:
Type your title here:
click here to go back
essay concept map
click here to continue

45

YOU HAVE MADE IT TO THE TOP OF THE MOUNTAIN !

This is the end of this method of learning how to write essays using HCP. You should be able to do them on your own now.

Keep the steps in mind:
1. Choose the genre.
2. Select a language register: (intended audience, style, verb tense, pronoun)
3. Select your concepts and relational statements from a concept map.

I hope you enjoyed this form of ***mountaineering!*** Now you are at the top of the mountain of knowledge about Year 11 magnetics you can look around and see how to write many other types of essays. ***Happy writing!***

Whenever you want to quit out of the program, go under FILE down to QUIT.

click here to go back

Click here to start again

```
on mouseUp
  show menubar
  global extra,oncevar
  put "now" into oncevar
  put 50 into extra

  set blindtyping to true
  delete menu "font"
  delete menu "style"

  delete menu "go"

  delete menuitem "New Stack..." of menu "File"

  delete menuitem "Save a Copy..." of menu "File"
  delete menuitem "Compact Stack" of menu "File"
  delete menuitem "Protect Stack..." of menu "File"
  delete menuitem "Delete Stack..." of menu "File"

  delete menuitem "Print Stack..." of menu "File"
  delete menuitem "Print Report..." of menu "File"

  set enabled of menu "Edit" to false

  delete menu "Tools"

  delete menu "objects"


  create menu "mapping"
  put "go back" into menu "mapping"
  put "new concept" after menuitem "go back" of menu "mapping"
  put "erase concept" after menuitem "new concept" of menu "mappi
  put "list of concepts" after menuitem "erase concept" of menu '
  put "new relationship" after menuitem "list of concepts" of mer
  put "erase relationship" after menuitem "new relationship" of n
  put "list of relational statements" after menuitem "erase relat
  put "line" after menuitem "list of relational statements" of me
  put "finished drawing lines" after menuitem "line" of menu "map
  put "erase lines" after menuitem "finished drawing lines" of me
  put "finished erasing" after menuitem "erase lines" of menu "mc
  put "next concept map" after menuitem "finished erasing" of mer

  hide scroll window
  go to stack "magnetics 2"
end mouseUp
```

16 PM Script of card button id 2 = "Begin here"

```
on mouseUp
  visual effect scroll left
  go to next card
end mouseUp
```

5 PM Script of card id 16910 = "1"

```
on opencard
  global mapping1,mapping2,mapping3,mapping4,mapping5,mapping6,ma
  global mapping8,mapping9,mapping10
  put "f" into mapping1
  put "f" into mapping2
  put "f" into mapping3
  put "f" into mapping4
  put "f" into mapping5
  put "f" into mapping6
  put "f" into mapping7
  put "f" into mapping8
  put "f" into mapping9
  put "f" into mapping10
end opencard
```

PM Script of bkgnd button id 1 = ""

```
on mouseUp
  visual effect venetian blinds very slow
  go to card id 16910
end mouseUp
```

PM Script of card button id 6 = "Reading texts"

```
on mouseUp

   go to cd 20 of stack "magnetics 2"
end mouseUp
```

PM Script of card button id 9 = "essay concept map"

```
on mouseUp
   --global scrolloc
   push card
   go to cd one of stack "magnetics 1"
end mouseUp
```

PM Script of card button id 5 = "Writing task"

```
on mouseUp

   go to cd 30 of stack "magnetics 2"
end mouseUp
```

PM Script of card button id 10 = "essay typing"

```
on mouseUp
   go cd 42 of stack "magnetics 2"
end mouseUp
```

PM Script of card id 3041 = "first"

```
on idle
   put the selectedChunk into saveSelect
   moveTicker
   select saveSelect
end idle
on moveTicker
   put card field "Ticker" into saveText
   lock screen
   put char 1 of saveText after card field "Ticker"
   delete char 1 of card field "Ticker"
   unlock screen
end moveTicker
```

' PM Script of card button id 7 = ""

```
on mouseUp
   flash 4
   wait 10
   play "harpsichord" tempo 80 "c4 e g"
end mouseUp
```

tPMof stack Cronin 80mB:HCPmaster:HCPmaster:HCPmagnetics:HCPcommence

```
on openstack
   hide menubar
   get the userLevel
   set userLevel to 4
end openstack
```

```
on openstack
  get the userLevel
  set userLevel to 4

  hide scroll window

end openstack

on domenu menuchoice


   global  holder,keeper,chair,con,pot,mapping1,mapping2,mapping3,m
   global  mapping5,  mapping6,  mapping7,mapping8,mapping9,maptype,c


  if menuchoice is "new concept" then
    if mapping1 <> "f" then

      choose browse tool
      ask "Enter the new concept"
      put it into keeper
      put keeper into con
      put 1 into pot
      put "n" into maptype
      domenu new button
      put 2 into pot
      choose browse tool
    end if


  end if

  if menuchoice is "new relationship" then
    if mapping2 <> "f" then

      choose browse tool
      ask "What is the new relationship"
      put it into keeper
      put keeper into con
      put 1 into pot
      domenu new button
      put 2 into pot
      choose browse tool
    end if

  end if
  if menuchoice is "erase concept" then
    if mapping5 <> "f" then
      choose browse tool
      put 1 into chair
    end if

  end if
  if menuchoice is "erase relationship" then
    if mapping6 <> "f" then
      choose browse tool
      put 1 into chair
```

```
      end if

    end if
    if menuchoice is "finished erasing" then
      if mapping8 <> "f" then
        choose browse tool
        if oncevar = "now" then
          delete menu "paint"
          delete menu "options"
          delete menu "patterns"
        end if
        put "gone" into oncevar

      end if

    end if
    if menuchoice is "finished drawing lines" then
      if mapping10 <> "f" then
        choose browse tool
        if oncevar = "now" then
          delete menu "paint"
          delete menu "options"
          delete menu "patterns"
        end if
        put "gone" into oncevar

      end if
    end if

    if menuchoice is "erase lines" then
      if mapping3 <> "f" then
        choose eraser tool
        if oncevar = "now" then
          delete menu "paint"
          delete menu "options"
          delete menu "patterns"
        end if
        put "gone" into oncevar

      end if

    end if
    if menuchoice is "line" then
      if mapping4 <> "f" then
        choose line tool
        if oncevar = "now" then
          delete menu "paint"
          delete menu "options"
          delete menu "patterns"
        end if
        put "gone" into oncevar

      end if

    end if
    if menuchoice is "list of concepts" then
      if mapping7 <> "f" then
```

```
        choose browse tool
        create menu "List of Concepts"

        put "north pole" into menu "list of concepts"
        put "south pole" after menuitem "north pole" of menu "list
        put "iron filings" after menuitem "south pole" of menu "lis
        put "magnetism" after menuitem "iron filings" of menu "list
        put "attraction" after menuitem "magnetism" of menu "list c
        put "bar magnet" after menuitem "attraction" of menu "list
        put "repulsion" after menuitem "bar magnet" of menu "list c
        put "EM wave theory" after menuitem "repulsion" of menu "li
        put "electromagnet" after menuitem "EM wave theory" of menu
        put "magnetic field" after menuitem "electromagnet" of menu
        put "induced current" after menuitem "magnetic field" of me
    end if

  end if
  if menuchoice is "list of relational statements" then
    if mapping9 <> "f" then
      choose browse tool
      create menu "List of Relational statements"
      put "has" into menu "list of relational statements"
      put "used in"after menuitem "has" of menu "list of relatio
      put "is an example of" after menuitem "used in" of menu "l
      put "contains" after menuitem "is an example of" of menu "
      put "belongs to" after menuitem "contains" of menu "list o
      put "is measured by" after menuitem "belongs to" of menu "
      put "is the property of" after menuitem "is measured by" o
      put "causes"after menuitem "is the property of" of menu "l
      put "for" after menuitem "causes" of menu "list of relatio
      put "and" after menuitem "for" of menu "list of relational
      put "not" after menuitem "and" of menu "list of relational
      put "because" after menuitem "not" of menu "list of relati
      put "or" after menuitem "because" of menu "list of relatio
      put "yet" after menuitem "or" of menu "list of relational
      put "so" after menuitem "yet" of menu "list of relational
      put "by Amperes Law" after menuitem "so" of menu "list of
      put "by magnetic flux rule" after menuitem "by Amperes Law
      put "by magnetic strength rule" after menuitem "by magneti
      put "by induced emf rule" after menuitem "by magnetic stre
    end if

  end if

  pass domenu

end domenu
on newbutton

  global holder,shaka,counter
```

```
    set the name of the target to holder
    set the showname of the target to true
    set the style of the target to transparent
    set the width of the target to 60
    set the height of the target to 40

    put the id of button holder into shaka
    put 1 into counter
  end newbutton
```

```
on opencard

    global  mapping1,mapping2,mapping3,mapping4,mapping5,mapping6,ma
    global  mapping8,mapping9,mapping10
   put "t" into mapping1
   put "t" into mapping2
   put "t" into mapping3
   put "t" into mapping4
   put "t" into mapping5
   put "t" into mapping6
   put "t" into mapping7
   put "t" into mapping8
   put "t" into mapping9
   put "t" into mapping10


end opencard
on domenu menuchoice
   global con,pot
   if menuchoice is "north pole" then
      set the loc of cd btn "north pole" to 275,150
      show cd btn "north pole"
   end if
   if menuchoice is "south pole" then
      set the loc of cd btn "south pole" to 275,150
      show cd btn "south pole"
   end if
   if menuchoice is "iron filings" then
      set the loc of cd btn "iron filings" to 275,150
      show cd btn "iron filings"
   end if
   if menuchoice is "magnetism" then
      set the loc of cd btn "magnetism" to 275,150
      show cd btn "magnetism"
   end if
   if menuchoice is "attraction" then
      set the loc of cd btn "attraction" to 275,150
      show cd btn "attraction"
   end if
   if menuchoice is "bar magnet" then
      set the loc of cd btn "bar magnet" to 275,150
      show cd btn "bar magnet"
   end if
   if menuchoice is "repulsion" then
      set the loc of cd btn "repulsion" to 275,150
      show cd btn "repulsion"
   end if
   if menuchoice is "EM wave theory" then
      set the loc of cd btn "EM wave theory" to 275,150
      show cd btn "EM wave theory"
   end if
   if menuchoice is "electromagnet" then
      set the loc of cd btn "electromagnet" to 275,150
      show cd btn "electromagnet"
   end if
   if menuchoice is "magnetic field" then
      set the loc of cd btn "magnetic field" to 275,150
```

```
    show cd btn "magnetic field"
  end if
  if menuchoice is "induced current" then
    set the loc of cd btn "induced current" to 275,150
    show cd btn "induced current"
  end if


  if menuchoice is "has" then
    put 1 into pot
    put menuchoice into con
    domenu new button
  end if
  if menuchoice is "used in" then
    put 1 into pot
    put menuchoice into con
    domenu new button
  end if
  if menuchoice is "is an example of" then
    put 1 into pot

    put menuchoice into con
    domenu new button
  end if
  if menuchoice is "contains" then
    put 1 into pot
    put menuchoice into con
    domenu new button
  end if
  if menuchoice is "belongs to" then
    put 1 into pot
    put menuchoice into con
    domenu new button
  end if
  if menuchoice is "is measured by" then
    put 1 into pot
    put menuchoice into con
    domenu new button
  end if
  if menuchoice is "is the property of" then
    put 1 into pot
    put menuchoice into con
    domenu new button
  end if
  if menuchoice is "causes" then
    put 1 into pot
    put menuchoice into con
    domenu new button
  end if
  if menuchoice is "for" then
    put 1 into pot
    put menuchoice into con
    domenu new button
  end if
  if menuchoice is "and" then
    put 1 into pot
    put menuchoice into con
```

```
      domenu new button
    end if
    if menuchoice is "not" then
      put 1 into pot
      put menuchoice into con
      domenu new button
    end if
    if menuchoice is "because" then
      put 1 into pot
      put menuchoice into con
      domenu new button
    end if
    if menuchoice is "or" then
      put 1 into pot
      put menuchoice into con
      domenu new button
    end if
    if menuchoice is "yet" then
      put 1 into pot
      put menuchoice into con
      domenu new button
    end if
    if menuchoice is "so" then
      put 1 into pot
      put menuchoice into con
      domenu new button
    end if
    if menuchoice is "by magnetic strength rule" then
      put 1 into pot
      put menuchoice into con
      domenu new button
    end if
    if menuchoice is "by magnetic flux rule" then
      put 1 into pot
      put menuchoice into con
      domenu new button
    end if

    if menuchoice is "by induced emf rule" then
      put 1 into pot
      put menuchoice into con
      domenu new button


    end if
    pass domenu

end domenu
on mousestilldown
    global shaka,chair
    if chair = 1 then



      hide the target
      choose browse tool
      put 2 into chair
```

```
      exit to hypercard

    end if

    set the loc of the target to the mouseloc


  end mousestilldown
  on newbutton
     global con,shaka,pot,maptype,scrolloc,keeper,scale,extra

    if pot = 1 then

      set the name of the target to con
      put the id of the target into murder
      if scale = 666 then
        set the loc of button id murder to 100,extra
      end if
      put 999 into scale
      set the showname of the target to true
      ---- new lines
      if maptype = "n" then
        set the style of the target to roundrect
      else
        set the style of the target to transparent
      end if
      ---end of new lines

      set the width of the target to 135
      set the height of the target to 15
      if maptype = "n" then
        set textstyle of button con to plain
      else

        set textstyle of button con to italic
      end if
      put the id of button con into shaka
      choose browse tool
      put 2 into pot
      put "d" into maptype
    end if
  end newbutton
```

PM Script of card button id 3 = "Click here to go back"

```
on mouseUp
   visual effect scroll right
   go to previous card
end mouseUp
```

PM Script of card button id 2 = "Click here to continue"

```
on mouseUp
   visual effect scroll left
   go to next card
end mouseUp
```

```
on mouseStilldown
  show cd fld "def of north pole"
end mouseStilldown
on MouseUp
  hide cd fld "def of north pole"
end mouseUp
```

AM Script of card field id 1 = "alpha"

```
on mousedown
   global scrolloc,keeper,pot,maptype,zap,con,scale,extra,rabbit


   select the clickchunk
   get the value of the clickchunk

   set lockscreen to true
   push cd
   go to cd scrolloc of stack "magnetics 1"
   put it into keeper
   put keeper into con
   put 1 into pot
   put "n" into maptype
   put 666 into scale

   domenu new button


   choose browse tool
   put extra+10 into extra
   pop cd

   set lockscreen to false

end mousedown
```

AM Script of card button id 7 = "essay concept map"

```
on mouseUp
   global scrolloc
   push card
   go to cd scrolloc of stack "magnetics 1"
end mouseUp
```

```
on openstack
  get the userLevel
  set userLevel to 4
  show scroll window
end openstack

on domenu menuchoice
   global holder,keeper,chair,con,pot,mapping1,mapping2,mapping3,m
   global mapping5, mapping6, mapping7,mapping8,mapping9,maptype,c


  if menuchoice is "new concept" then
    if mapping1 <> "f" then
      choose browse tool
      ask "Enter the new concept"
      put it into keeper
      put keeper into con
      put 1 into pot
      put "n" into maptype
      domenu new button
      put 2 into pot
      choose browse tool
    end if
  end if

  If menuchoice is "next concept map" then
    go to the next card
  end if

  if menuchoice is "new relationship" then
    if mapping2 <> "f" then

      choose browse tool
      ask "What is the new relationship"
      put it into keeper
      put keeper into con
      put 1 into pot
      domenu new button
      put 2 into pot
      choose browse tool
    end if

  end if
  if menuchoice is "erase concept" then
    if mapping5 <> "f" then
      choose browse tool
      put 1 into chair
    end if

  end if
  if menuchoice is "erase relationship" then
    if mapping6 <> "f" then
      choose browse tool
      put 1 into chair
    end if

  end if
```

```
 if menuchoice is "go back" then
   pop card
 end if

 if menuchoice is "finished erasing" then
   if mapping8 <> "f" then
     choose browse tool
     if oncevar = "now" then
       delete menu "paint"
       delete menu "options"
       delete menu "patterns"
     end if
     put "gone" into oncevar

   end if

 end if
 if menuchoice is "finished drawing lines" then
   if mapping10 <> "f" then
     choose browse tool
     if oncevar = "now" then
       delete menu "paint"
       delete menu "options"
       delete menu "patterns"
     end if
     put "gone" into oncevar

   end if
 end if

 if menuchoice is "erase lines" then
   if mapping3 <> "f" then
     choose eraser tool
     if oncevar = "now" then
       delete menu "paint"
       delete menu "options"
       delete menu "patterns"
     end if
     put "gone" into oncevar

   end if

 end if
 if menuchoice is "line" then
   if mapping4 <> "f" then
     choose line tool
     if oncevar = "now" then
       delete menu "paint"
       delete menu "options"
       delete menu "patterns"
     end if
     put "gone" into oncevar

   end if

 end if
 if menuchoice is "list of concepts" then
```

```
      if mapping7 <> "f" then
        choose browse tool
        create menu "List of Concepts"

        put "north pole" into menu "list of concepts"
        put "south pole" after menuitem "north pole" of menu "list
        put "iron filings" after menuitem "south pole" of menu "lis
        put "magnetism" after menuitem "iron filings" of menu "list
        put "attraction" after menuitem "magnetism" of menu "list c
        put "bar magnet" after menuitem "attraction" of menu "list
        put "repulsion" after menuitem "bar magnet" of menu "list c
        put "EM wave theory" after menuitem "repulsion" of menu "li
        put "electromagnet" after menuitem "EM wave theory" of menu
        put "magnetic field" after menuitem "electromagnet" of menu
        put "induced current" after menuitem "magnetic field" of me
      end if

    end if
    if menuchoice is "list of relational statements" then
      if mapping9 <> "f" then
        choose browse tool
        create menu "List of Relational statements"
        put "has" into menu "list of relational statements"
        put "used in"after menuitem "has" of menu "list of relatio
        put "is an example of" after menuitem "used in" of menu "l
        put "contains" after menuitem "is an example of" of menu "
        put "belongs to" after menuitem "contains" of menu "list o
        put "is measured by" after menuitem "belongs to" of menu "
        put "is the property of" after menuitem "is measured by" o
        put "causes"after menuitem "is the property of" of menu "l
        put "for" after menuitem "causes" of menu "list of relatio
        put "and" after menuitem "for" of menu "list of relational
        put "not" after menuitem "and" of menu "list of relational
        put "because" after menuitem "not" of menu "list of relati
        put "or" after menuitem "because" of menu "list of relatio
        put "yet" after menuitem "or" of menu "list of relational
        put "so" after menuitem "yet" of menu "list of relational
        put "by Amperes Law" after menuitem "so" of menu "list of
        put "by magnetic flux rule" after menuitem "by Amperes Law
        put "by magnetic strength rule" after menuitem "by magneti
        put "by induced emf rule" after menuitem "by magnetic stre
      end if


    end if


    pass domenu

  end domenu
  on newbutton
    global holder,con,shaka,pot,maptype,scrolloc,keeper,scale,extra
    if pot = 1 then

      set the name of the target to con
      set the showname of the target to true
      set the style of the target to transparent
```

```
set the width of the target to 180
set the height of the target to 15
if maptype = "n" then
   set textstyle of button con to 100,50

   put the id of button holder into shaka
   choose browse tool
   put 2 into pot
end if
end newbutton
```

```
on opencard
   set enabled of menu "Edit" to true
   delete menuitem "New Card" of menu "Edit"
   delete menuitem "Delete Card" of menu "Edit"
   delete menuitem "Cut Card" of menu "Edit"
   delete menuitem "Copy Card" of menu "Edit"
   delete menuitem "Background" of menu "Edit"
   delete menuitem "Icon..." of menu "Edit"



   delete menuitem "Audio..." of menu "Edit"
   delete menuitem "Audio Help" of menu "Edit"



   set lockText of cd fld "38-2" to false


    global mapping1,mapping2,mapping3,mapping4,mapping5,mapping6,ma
    global mapping8,mapping9,mapping10,scrolloc
   put "f" into mapping1
   put "f" into mapping2
   put "f" into mapping3
   put "f" into mapping4
   put "f" into mapping5
   put "f" into mapping6
   put "f" into mapping7
   put "f" into mapping8
   put "f" into mapping9
   put "f" into mapping10
   put "one" into scrolloc


end opencard
on closecard
   set enabled of menu "Edit" to false
   put "New Card" after menuitem "Undo" of menu "Edit"
   put "Delete Card" after menuitem "New Card" of menu "Edit"
   put "Cut Card" after menuitem "Delete Card" of menu "Edit"
   put "Copy Card" after menuitem "Cut Card" of menu "Edit"
   put "Background" after menuitem "Copy Card" of menu "Edit"
   put "Icon..." after menuitem "Background" of menu "Edit"



   put "Audio..." after menuitem "Icon..." of menu "Edit"
   put "Audio Help" after menuitem "Audio..." of menu "Edit"

end closecard
```

```
on mouseUp
  -----------------------THIS IS THE SPELLING CHECKER


  global alphabetletter,scanno
  --- alphabetletter is the current first letter of words that is
  --- scanno is the line number of the appropiate letter in the c
  --- now put in termination words which will be erased at end



  put " aq bq cq dq eq fq gq hq iq jq kq lq mq nq oq pq qq rq sq
  ---
  --- now start letter search
  put a into alphabetletter
  put 1 into scanno
  scan
  put b into alphabetletter
  put 2 into scanno
  scan
  put c into alphabetletter
  put 3 into scanno
  scan

  put d into alphabetletter
  put 4 into scanno
  scan
  put e into alphabetletter
  put 5 into scanno
  scan
  put f into alphabetletter
  put 6 into scanno
  scan

  put g into alphabetletter
  put 7 into scanno
  scan
  put h into alphabetletter
  put 8 into scanno
  scan
  put i into alphabetletter
  put 9 into scanno
  scan
  put j into alphabetletter
  put 10 into scanno
  scan
  put k into alphabetletter
  put 11 into scanno
  scan
  put l into alphabetletter
  put 12 into scanno
  scan
  put m into alphabetletter
  put 13 into scanno
  scan
  put n into alphabetletter
  put 14 into scanno
```

```
    scan
    put o into alphabetletter
    put 15 into scanno
    scan
    put p into alphabetletter
    put 16 into scanno
    scan
    put q into alphabetletter
    put 17 into scanno
    scan
    put r into alphabetletter
    put 18 into scanno
    scan
    put s into alphabetletter
    put 19 into scanno
    scan
    put t into alphabetletter
    put 20 into scanno
    scan
    put u into alphabetletter
    put 21 into scanno
    scan
    put v into alphabetletter
    put 22 into scanno
    scan
    put w into alphabetletter
    put 23 into scanno
    scan
    put x into alphabetletter
    put 24 into scanno
    scan
    put y into alphabetletter
    put 25 into scanno
    scan
    put z into alphabetletter
    put 26 into scanno
    scan
    ---
    --- now erase the termination words
    repeat 26 times
      put "" into the last word of cd fld "test"
    end repeat



    hide msg
    show cd btn "Now finished, click here"
    exit to hypercard

  end mouseup

  on scan

    global compare,g,h,alphabetletter,scanno,foundchunk
    --- compare is the word lifted from the essay
    --- scanno is the line number of the appropiate letter in the c
    --- alphabetletter is the current first letter of words that is
```

```
--- g is ?
--- h is ?
--- now see if there are no words starting with the letter alpl
--- in the correct word field
if item 2 of line scanno of cd fld "correct" = 9 then
  exit scan
end if
---
put 1 into g
put 1 into h
put 0 into foundtext
--- now to make each letter search start at the start of the es
select before the first char of cd fld "test"
---
repeat
  ---- now getting a word that starts with the letter
  find alphabetletter in cd fld "test" of marked cards
  put the foundchunk into cd fld "helper"
  put the foundtext into compare
  ----- now a way of stopping the search
  if the foundtext = "aq" then
    exit scan
  end if
  if the foundtext = "aq" then
    exit scan
  end if
  if the foundtext = "bq" then
    exit scan
  end if
  if the foundtext = "cq" then
    exit scan
  end if
  if the foundtext = "dq" then
    exit scan
  end if
  if the foundtext = "eq" then
    exit scan
  end if
  if the foundtext = "fq" then
    exit scan
  end if
  if the foundtext = "gq" then
    exit scan
  end if
  if the foundtext = "hq" then
    exit scan
  end if
  if the foundtext = "iq" then
    exit scan
  end if
  if the foundtext = "jq" then
    exit scan
  end if
  if the foundtext = "kq" then
    exit scan
  end if
  if the foundtext = "lq" then
```

```
    exit scan
  end if
  if the foundtext = "mq" then
    exit scan
  end if
  if the foundtext = "nq" then
    exit scan
  end if
  if the foundtext = "oq" then
    exit scan
  end if
  if the foundtext = "pq" then
    exit scan
  end if
  if the foundtext = "qq" then
    exit scan
  end if
  if the foundtext = "rq" then
    exit scan
  end if
  if the foundtext = "sq" then
    exit scan
  end if
  if the foundtext = "tq" then
    exit scan
  end if
  if the foundtext = "uq" then
    exit scan
  end if
  if the foundtext = "vq" then
    exit scan
  end if
  if the foundtext = "wq" then
    exit scan
  end if
  if the foundtext = "xq" then
    exit scan
  end if
  if the foundtext = "yq" then
    exit scan
  end if
  if the foundtext = "zq" then
    exit scan
  end if
  ------
  ---- now check if word is more than 4 characters
  ---- if word is 4 or less then ignore it
  put word 2 of line 1 of cd fld "helper" into var1
  put word 4 of line 1 of cd fld "helper" into var2
  put (var2 - var1) + 1 into store
  ---- if it is more than four the sub routine checker is acti\
  if store > 4 then checker
  ----- now tidy up for the next word
  delete line 1 of cd fld "helper"
  ----- the line below is critical for the programme to call it
  put "find alphabetletter in cd fld test of this card" into ms
  ---- the moving on part - that is finding and analysing all c
```

```
---- words in essay that start with alphabetletter
repeat
  ---- activating the msg in the message box
  send returnkey to cd "student1"
  ----
  put the foundchunk into cd fld "helper"
  put the foundtext into compare
  ----- now a way of stopping the search
  if the foundtext = "aq" then
    exit scan
  end if
  if the foundtext = "aq" then
    exit scan
  end if
  if the foundtext = "bq" then
    exit scan
  end if
  if the foundtext = "cq" then
    exit scan
  end if
  if the foundtext = "dq" then
    exit scan
  end if
  if the foundtext = "eq" then
    exit scan
  end if
  if the foundtext = "fq" then
    exit scan
  end if
  if the foundtext = "gq" then
    exit scan
  end if
  if the foundtext = "hq" then
    exit scan
  end if
  if the foundtext = "iq" then
    exit scan
  end if
  if the foundtext = "jq" then
    exit scan
  end if
  if the foundtext = "kq" then
    exit scan
  end if
  if the foundtext = "lq" then
    exit scan
  end if
  if the foundtext = "mq" then
    exit scan
  end if
  if the foundtext = "nq" then
    exit scan
  end if
  if the foundtext = "oq" then
    exit scan
  end if
  if the foundtext = "pq" then
```

```
      exit scan
    end if
    if the foundtext = "qq" then
      exit scan
    end if
    if the foundtext = "rq" then
      exit scan
    end if
    if the foundtext = "sq" then
      exit scan
    end if
    if the foundtext = "tq" then
      exit scan
    end if
    if the foundtext = "uq" then
      exit scan
    end if
    if the foundtext = "vq" then
      exit scan
    end if
    if the foundtext = "wq" then
      exit scan
    end if
    if the foundtext = "xq" then
      exit scan
    end if
    if the foundtext = "yq" then
      exit scan
    end if
    if the foundtext = "zq" then
      exit scan
    end if
    ------
    ----- now to check if word is greater than 4 chars long
    put word 2 of line 1 of cd fld "helper" into var1
    put word 4 of line 1 of cd fld "helper" into var2
    put (var2 - var1) + 1 into store
    ----- if it is then go to routine checker
    if store > 4 then checker
    ----- tidying up for next word from essay
    delete line 1 of cd fld "helper"
  end repeat
 end repeat
end scan

on checker
  global compare,counter,g,h,quick,scanno
  ---- compare is the word from the essay
  ---- scanno is the line of correct spelling fld 'correct'
  ---- counter is ?
  ---- g is ?
  ---- h is ?
  ---- quick is ?
  put 0 into tickcorrect
  ---- tickcorrect is the word extracted from the correct spellin
  put 0 into permission
  put 2 into counter
```

```
    put 2 into quick
    ---- quick is used to go through items in a line of correct fld
    ---- now to check the word against correct spellings
    repeat until tickcorrect = "9"
      put item quick of line scanno of cd fld "correct" into tickc‹
      if tickcorrect = compare then
        put 5 into permission
        ---- the word matches on in the correct fld so get out of ‹
        exit checker
      end if
      put quick + 1 into quick
    end repeat
    ---- well the word from the essay does not match any in the cor
    ---- so now time to look at corresponence with correct words
    ---- the subroutine suggest is used for this
    suggest
    -----
  end checker
  on suggest
    global compare,scanno
    put 1 into clint
    ---- clint makes sure that if no suggestions the suggest fld do
    put 2 into counter
    put 0 into tickcorrect
    put 1 into g
    put 1 into h
    ---- compare is the word from the essay
    ---- scanno is the line of correct spelling fld 'correct'
    ---- counter is used to go through items in a line of the corre
    ---- g is ?
    ---- h is ?
    ---- tickcorrect is a word from the correct fld
    repeat until tickcorrect = "9"
      put item counter of line scanno of cd fld "correct" into ticl
      put 0 into ratiocorrect
      put 0 into ratioincorrect
      ---- now the word is spelt incorrectly so get ratio of matchi
      ---- to non-matching letters, not the positions of letters
      if tickcorrect <> compare then
        put 1 into sony
        repeat
          put char sony of tickcorrect into x
          if x = "" then
            exit repeat
            ----- no more characters in the word
          end if
          if compare contains x then
            put ratiocorrect + 1 into ratiocorrect
          else
            put ratioincorrect + 1 into ratioincorrect
          end if
          put sony + 1 into sony
        end repeat
        put ratiocorrect/ratioincorrect into ratio
        ---- so now if ratio of matching letters to non matching is
        ---- least two to one then suggest a correction
        if ratio >= 2 then
```

```
          if ratio >= 2 then
            ---- now putting word in essay into fld appear1
            if clint = 1 then
              put compare into line 2 of cd fld "appear1"
            end if
            put 2 into clint
            ---- putting options into fld appear2 for student to se
            put tickcorrect into line g of cd fld "appear2"
            put g + 1 into g
          end if
        end if
        if ratio < 2 then
          put h+1 into h
        end if
      end if
      if tickcorrect <> "9" then
        ---- move to next item on the line in the correct fld
        put counter + 1 into counter
      end if
      if tickcorrect = "9" then
        if clint <> 1 then
          gawk
        end if
      end if
    end repeat
end suggest

on gawk
  global foundchunk


  ---- now to show the possible words to replace the word with
  set textalign of cd fld "appear1" to center
  show cd fld "appear1"
  show cd fld "appear2"
  show cd fld "appear3"
  ----- now waiting around for something to happen
  wait until the mouse is down
  ----- if the student decides not to replace the word
  if the clicktext = "Don't change" then
    hide cd fld "appear1"
    hide cd fld "appear2"
    hide cd fld "appear3"
    set the locktext of cd fld "appear2" to false
    put "" into word 1 of line 2 of cd fld "appear1"
    repeat 10 times
      delete line 1 of cd fld "appear2"
    end repeat
    exit gawk
  end if
  ------ attempting to intercept a click in no-man's land
  if the clicktext = "" then
    hide cd fld "appear1"
    hide cd fld "appear2"
    hide cd fld "appear3"
    set the locktext of cd fld "appear2" to false
    put "" into word 1 of line 2 of cd fld "appear1"
```

```
    repeat 10 times
      delete line 1 of cd fld "appear2"
    end repeat
    exit gawk
  end if
  ------ otherwise the students has selected a replacement word
  ----- which will now be put in
  put the clicktext into the foundchunk
  hide cd fld "appear1"
  hide cd fld "appear2"
  hide cd fld "appear3"
  set the locktext of cd fld "appear2" to false
  put "" into word 1 of line 2 of cd fld "appear1"
  repeat 10 times
    delete line 1 of cd fld "appear2"
  end repeat
end gawk
```

```
on mouseup
  ---------------------THIS IS THE GRAMMAR CHECKER

  ---- searching for its
  numberten
  ----- searching for it's
  numbereleven
  ----- searching for But
  numberfive
  ------ searching for And
  numbersix
  ----- searching for these
  numberseven
  ----- searching for this
  numbereight
  ----- searching for ,
  numberfour
  -----searching for full stop with no space after
  numbertwo
  ----- searching for a full stop with no capital after
  numberone
  hide msg
  show cd fld "paraspaces"
  wait 5 seconds
  hide cd fld "paraspaces"
  visual effect dissolve very slowly
  show cd btn "Now finished, click here"
  exit to hypercard
end mouseup


on numberten
  put " its zz" after the last word of cd fld "test" of cd "stude
  repeat
    find word "its" in cd fld "test"
    wait 1 second
    put the foundchunk into line 1 of cd fld "gone"
    put word 4 of line 1 of cd fld "gone" into gtrack
    put gtrack+2 into gtrack
    put char gtrack of cd fld "test" into gchecker
    if gchecker = "z" then
      put gtrack+1 into gtrack
      put char gtrack of cd fld "test" into gchecker
      if gchecker = "z" then
        delete the last word of cd fld "test"
        delete the last word of cd fld "test"
        exit repeat
      end if
    end if
    answer "Do you want this word to be it's?" with "Yes" or "No"
    if it is "Yes" then
      put "it's" into the foundchunk
    end if
  end repeat
end numberten
on numbereleven
  put " it's zz" after the last word of cd fld "test" of cd "stuc
```

```
    repeat
      find word "it's" in cd fld "test"
      wait 1 second
      put the foundchunk into line 1 of cd fld "gone"
      put word 4 of line 1 of cd fld "gone" into gtrack
      put gtrack+2 into gtrack
      put char gtrack of cd fld "test" into gchecker
      if gchecker = "z" then
        put gtrack+1 into gtrack
        put char gtrack of cd fld "test" into gchecker
        if gchecker = "z" then
          delete the last word of cd fld "test"
          delete the last word of cd fld "test"
          exit repeat
        end if
      end if
      answer "Do you want this word to be its?" with "Yes" or "No"
      if it is "Yes" then
        put "its" into the foundchunk
      end if
    end repeat
  end numbereleven
  on numberfive
    put " but zz" after the last word of cd fld "test" of cd "stude
    repeat
      find word "but" in cd fld "test"
      put the foundchunk into line 1 of cd fld "gone"
      put word 4 of line 1 of cd fld "gone" into gstop
      put gstop + 2 into gstop
      put char gstop of cd fld "test" into gchecker
      if gchecker = "z" then
        put gstop+1 into gstop
        put char gstop of cd fld "test" into gchecker
        if gchecker = "z" then
          delete the last word of cd fld "test"
          delete the last word of cd fld "test"
          exit repeat
        end if
      end if
      put word 2 of line 1 of cd fld "gone" into gtarget
      put char gtarget of cd fld "test" into gholder
      put the chartonum of gholder into gstore
      if gstore = 66 then
        wait 1 second
        answer "Do you want to replace this word?" with "Yes" or "N
        if it is "yes" then
          ask "Type in your new word"
          put it into the foundchunk
        end if
      end if
    end repeat
  end numberfive
  on numbersix
    put " and zz" after the last word of cd fld "test" of cd "stude
    repeat
      find word "and" in cd fld "test"
      put the foundchunk into line 1 of cd fld "gone"
```

```
        put word 4 of line 1 of cd fld "gone" into gstop
        put gstop + 2 into gstop
        put char gstop of cd fld "test" into gchecker
        if gchecker = "z" then
          put gstop+1 into gstop
          put char gstop of cd fld "test" into gchecker
          if gchecker = "z" then
            delete the last word of cd fld "test"
            delete the last word of cd fld "test"
            exit repeat
          end if
        end if
        put word 2 of line 1 of cd fld "gone" into gtarget
        put char gtarget of cd fld "test" into gholder
        put the chartonum of gholder into gstore
        if gstore = 65 then
          wait 1 second
          answer "Do you want to replace this word?" with "Yes" or "N
          if it is "yes" then
            ask "Type in your new word"
            put it into the foundchunk
          end if
        end if
      end repeat
    end numbersix
    on numberseven
      put " these zz" after the last word of cd fld "test" of cd "st
      repeat
        find word "these" in cd fld "test"
        put the foundchunk into line 1 of cd fld "gone"
        put word 4 of line 1 of cd fld "gone" into gholder
        put gholder + 2 into gstop
        put char gstop of cd fld "test" into gchecker
        if gchecker = "z" then
          put gstop+1 into gstop
          put char gstop of cd fld "test" into gchecker
          if gchecker = "z" then
            delete the last word of cd fld "test"
            delete the last word of cd fld "test"
            exit repeat
          end if
        end if
        put gholder + 2 into gholder
        find char gholder of cd fld "test"
        put the foundchunk into line 1 of cd fld "gone"
        put word 4 of line 1 of cd fld "gone" into gstore
        put char gstore of cd fld "test" into gholder
        put the chartonum of gholder into glook
        if glook <> 115 then
          wait 1 second
          answer "Do you want this word to be plural with s?" with "Y
          if it is "yes" then
            put "s" after char gstore of cd fld "test"
          end if
        end if
      end repeat
    end numberseven
```

```
on numbereight
  put " this zz" after the last word of cd fld "test" of cd "stuc
  repeat
    find word "this" in cd fld "test"
    put the foundchunk into line 1 of cd fld "gone"
    put word 4 of line 1 of cd fld "gone" into gholder
    put gholder + 2 into gstop
    put char gstop of cd fld "test" into gchecker
    if gchecker = "z" then
      put gstop+1 into gstop
      put char gstop of cd fld "test" into gchecker
      if gchecker = "z" then
        delete the last word of cd fld "test"
        delete the last word of cd fld "test"
        exit repeat
      end if
    end if
    put gholder + 2 into gholder
    find char gholder of cd fld "test"
    put the foundchunk into line 1 of cd fld "gone"
    put word 4 of line 1 of cd fld "gone" into gstore
    put char gstore of cd fld "test" into gholder
    put the chartonum of gholder into glook
    if glook = 115 then
      wait 1 second
      answer "Do you want this word to be singular without s?" wi
      if it is "yes" then
        delete char gstore of cd fld "test"
      end if
    end if
  end repeat
end numbereight
on numberfour
  put " , zz" after the last word of cd fld "test" of cd "student
  repeat
    find "," in cd fld "test"
    put the foundchunk into line 1 of cd fld "gone"
    wait 1 second
    put word 4 of line 1 of cd fld "gone" into gholder
    put gholder + 2 into gstop
    put char gstop of cd fld "test" into gchecker
    if gchecker = "z" then
      put gstop+1 into gstop
      put char gstop of cd fld "test" into gchecker
      if gchecker = "z" then
        delete the last word of cd fld "test"
        delete the last word of cd fld "test"
        exit repeat
      end if
    end if
    put word 2 of line 1 of cd fld "gone" into gcompare1
    put word 4 of line 1 of cd fld "gone" into gcompare2
    if gcompare1 <> gcompare2 then
      answer "Do you want a space after the comma?" with "Yes" or
      if it is "yes" then
        put " " after char gcompare1 of cd fld "test"
      end if
```

```
      end if
    end repeat
  end numberfour
  on numbertwo
    put " . zz" after the last word of cd fld "test" of cd "student
    repeat
      find "." in cd fld "test"
      put the foundchunk into line 1 of cd fld "gone"
      wait 1 second
      put word 4 of line 1 of cd fld "gone" into gholder
      put gholder + 2 into gstop
      put char gstop of cd fld "test" into gchecker
      if gchecker = "z" then
        put gstop+1 into gstop
        put char gstop of cd fld "test" into gchecker
        if gchecker = "z" then
          delete the last word of cd fld "test"
          delete the last word of cd fld "test"
          exit repeat
        end if
      end if
      put word 2 of line 1 of cd fld "gone" into gcompare1
      put word 4 of line 1 of cd fld "gone" into gcompare2
      if gcompare1 <> gcompare2 then
        answer "Do you want a space before the start of the senten(
        if it is "yes" then
          put " " after char gcompare1 of cd fld "test"
        end if
      end if
    end repeat
  end numbertwo
  on numberone
    put " . zz" after the last word of cd fld "test" of cd "student
    repeat 15 times
      find "." in cd fld "test"
      put the foundchunk into line 1 of cd fld "gone"
      wait 1 second
      put word 4 of line 1 of cd fld "gone" into gholder
      put gholder + 2 into gstop
      put char gstop of cd fld "test" into gchecker
      if gchecker = "z" then
        put gstop+1 into gstop
        put char gstop of cd fld "test" into gchecker
        if gchecker = "z" then
          delete the last word of cd fld "test"
          delete the last word of cd fld "test"
          exit repeat
        end if
      end if
      put gholder + 2 into gholder
      find char gholder of cd fld "test"
      put the foundchunk into line 1 of cd fld "gone"
      put word 2 of line 1 of cd fld "gone" into gstore
      put char gstore of cd fld "test" into gcomplex
      put the chartonum of gcomplex into glook
      if glook ≥ 97 then
        if glook ≤ 122 then
```

```
        wait 1 second
         answer "Do you want a capital letter here?" with "Yes" or
        if it is "yes" then
          put glook - 32 into glook
           put numtochar(glook) into char gstore of cd fld "test"
        end if
      end if
    end if
  end repeat
end numberone
```

```
on mouseUp
  ----------------THIS IS THE COUNTER CHECKER


  global wordy,sentency,pary,sentbig,sixy,raty
  answer "Do you wish to count all words?" with "Yes" or "No"
  if it is "Yes" then put 234 into wordy
  answer "Do you wish to count all sentences?" with "Yes" or "No"
  if it is "Yes" then put 234 into sentency
  answer "Do you wish to count paragraphs?" with "Yes" or "No"
  if it is "Yes" then put 234 into pary
  answer "Do you wish to count sentences of more than 20 words?"
  "Yes" or "No"
  if it is "Yes" then put 234 into sentbig
  answer "Do you wish to count words of more than 6 letters?" wit
  "Yes" or "No"
  if it is "Yes" then put 234 into sixy
  answer "Do you wish to calculate a minimum mark?" ¬
  with "Yes" or "No"
  if it is "Yes" then put 234 into raty
  show cd fld "tidy"
  show cd fld "hang"
  put shaka after the last char of cd fld "test"
  put 1 into cx
  put 0 into wordcount
  put 0 into wordsix
  put 0 into sentences
  put 0 into longsentence
  put 0 into sentword
  ---- wordcount keeps track of number of words.
  ---- wordsix keeps track of number of words that are
  ---- six or more characters long.
  ---- sentences keeps track of the number of sentences
  ---- longsentence keeps track of number of sentences consisting
  ---- of 20 or more words
  ---- sentword keeps track of number of words per sentence
  select before the first char of cd fld "test"
  repeat
    ---- counting all words
    find word cx of cd fld "test"
    if the foundtext = "shaka" then
      exit repeat
    end if
    put wordcount + 1 into wordcount
    put sentword + 1 into sentword
    put the foundtext into cd fld "clist"
    ---- need the foundchunk to work out word length
    put the foundchunk into cd fld "ccompare"
    put word 2 of line 1 of cd fld "ccompare" into holder1
    put word 4 of line 1 of cd fld "ccompare" into holder2
    ----- now is that word six or more characters long?
    put holder2 - holder1 + 1 into holder3
    ----- if it is then
    if holder3 > 5 then
      ---- we better check to see if that last char is a full stc

      get character holder2 of line 1 of cd fld "test"
```

```
        if it = "." then

          put sentences + 1 into sentences

          if sentword ≥ 20 then
            put longsentence + 1 into longsentence
          end if
          put 0 into sentword
          put holder3 - 1 into holder3
          if holder3 > 5 then
            put wordsix + 1 into wordsix
          end if
        end if
        if it = "," then
          put holder3 - 1 into holder3
          if holder3 > 5 then
            put wordsix + 1 into wordsix
          end if
        end if
        if it <> "." then
          if it <> "," then
            put wordsix + 1 into wordsix
          end if
        end if

      end if

      put cx+1 into cx
    end repeat
    hide cd fld "hang"
    if wordy = 234 then
      show cd fld "tidy"
      show cd fld "word count1"
      put wordcount - 16 into line 1 of cd fld "word count2"
      show cd fld "word count2"
    end if
    if sentency = 234 then
      show cd fld "tidy"
      show cd fld "sentences1"
      ------put sentences into line 1 of cd fld "sentences2"
      put "N/A" into line 1 of cd fld "sentences2"
      show cd fld "sentences2"
    end if
    ----Activate when paragraph count operational
    ---if pary = 234 then
    ---show cd fld "tidy"
    ---show cd fld "paras1"
    ---put paranumber into line 1 of cd fld "paras2"
    ----show cd fld "paras2"
    ----end if
    if sentbig = 234 then
      show cd fld "tidy"
      show cd fld "bigones1"
      ----put longsentence into line 1 of cd fld "bigones2"
      put "N/A" into line 1 of cd fld "bigones2"
      show cd fld "bigones2"
    end if
```

```
    if sixy = 234 then
       show cd fld "tidy"
       show cd fld "bigwords1"
       put wordsix into line 1 of cd fld "bigwords2"
       show cd fld "bigwords2"
    end if
    if raty = 234 then
       --put wordsix/wordcount into ratio
       --put ratio * 100 into rati
       ---put wordsix/10 - longsentence + (wordcount*sentences*/100)
       put (wordcount+sentences+wordsix-longsentence)/50 into ratio
       show cd fld "tidy"
       show cd fld "ratio1"
       put ratio into line 1 of cd fld "ratio2"
       show cd fld "ratio2"
    end if
    delete the last word of cd fld "test"
    hide cd fld "hang"
    ----show cd btn "Click here to go on"
    ----exit to hypercard
    hide msg
    show cd btn "Now finished, click here"
    exit to hypercard

end mouseUp
```

Appendix 5.5a
Letters of permission

The letters of permission were gained from the principals of the participating schools and from the Administrative Services Branch of the Education Department for the Department schools. This letter is just one example.

Appendix 5.5b
The Agreement for Privacy provisions

Further letters of permission were given (pages 91 to 95) as the project was extended into other schools in the first and second extended studies. The Agreement of Privacy was fully complied with as shown by the appended note signed 5th. July 1994 on page 91 which was signed at the end of the project.

[redacted]

23rd July, 1991

Brother Pat Cronin,
Christian Brothers,
103A George Street,
THEBARTON. S.A. 5031

Dear Pat,

[redacted] I am delighted to support your request to work with [redacted] in our year 11 Physics programme. I am sure we will gain much and if the involvement helps with your studies it will no doubt be an added bonus.

I look forward to seeing you around the school next term.

Regards,

[redacted]

R. 11/11/91

DIRECTOR-GENERAL OF EDUCATION
SOUTH AUSTRALIA

P.O. Box 1152
[illegible]delaide, S.A. 5001
[illegible]lephone: (08) 226 1466
[illegible]csimile: (08) 226 1118
[illegible] reply please quote

Education Centre
31 Flinders Street
Adelaide 5000

[illegible]f ED 3/38/57G
wp+294/admin

Date: 28/10/91

(Br) P. Cronin
Christian Brothers
103A George Street
THEBARTON 5031

Dear Br Cronin

I refer to your letter of October 17, concerning your request for permission to undertake a science research project at [redacted]

I am happy to approve your application as the outcome should be of benefit to students and teachers involved in the curriculum area concerned.

It is noted that access to records is not requested and that no personal information is being collected. It would however be in keeping with the philosophy inherent in the Cabinet Instructions relating to Privacy if students were informed of procedures in advance and their cooperation sought. Students should have the right to be able to discuss their test results with the class teacher if that is what they desire.

It is a condition of approval that a copy of your research product must be provided to the Education Department before and after publication. I would ask you to sign the enclosed undertaking and return it to the Records Management Officer, Administrative Services Branch.

I wish you well with your project.

Yours sincerely

/ for [signature]
Ken Boston
DIRECTOR-GENERAL OF EDUCATION

I have reviewed the thesis for Br Cronin and found that it complies with Departmental policy on Privacy Principles

[signature]
Freedom of Information Delegate.
5. July 9[illegible]

EDUCATION DEPARTMENT OF SOUTH AUSTRALIA

UNDERTAKING TO PRESERVE THE ANONYMITY OF A RECORD-SUBJECT IN RESEARCH

I, ..Patrick Cronin........ of ..103A George St. ......Thebarton SA........................ recognise that the information contained in the records of the Education Department of South Australia is confidential and I hereby undertake not to reveal any personal information that may identify or could assist in identifying a person named in the records.

I undertake to submit to the Education Department of South Australia a true copy of the research product before it is published to ensure that the identity of any person is not disclosed and cannot be ascertained and will provide a true copy of the authorised research product as soon as practicable after its publication.

At the completion of my research I undertake to destroy any working notes, draft reports or copies of agency information that identifies any person or might be used to determine the identity of any person.

I understand that any breach of this undertaking may result in my being denied further access for research purposes.

DATED this ..12-11.... day of ....November.. 1991

Signature ..P Cronin

Address ..103 A George St ..Thebarton

Telephone No. 352 5658

WITNESS

Signature ....J W Gee.......

Address ......103A George St ......Thebarton 5031

Telephone No. .....3525658.....

Researcher Approved: ....

Chairperson

Privacy Committee

.../.../...

DIRECTOR-GENERAL OF EDUCATION
SOUTH AUSTRALIA

G.P.O. Box 1152
Adelaide, S.A. 5001
Telephone: (08) 226 1466
Facsimile: (08) 226 1118
In reply please quote
Ref. ED 3/40/ WP+347/Admin

Education Cent
31 Flinders Stre
Adelaide 50(

17 SEP 1992

Br Patrick Cronin
Christian Brothers
I03A George Street,
THEBARTON, S.A. 5031

Dear Br Cronin,

I refer to your letter of 27 July, 1992, in which you seek approval to extend your research project on science education.

I am happy to approve your application as the outcomes should be of benefit to the Department. I attach a copy of your undertaking to maintain the anonymity of your record subjects and remind you that you have agreed to provide a copy of your research product before and after publication. The terms and conditions of your original approval remain current.

I wish you well with your project.

Yours sincerely

Eric Willmot
DIRECTOR-GENERAL OF EDUCATION

Education Department of South Australia

31 Flinders Street
Adelaide
South Australia 5000
GPO Box 1152 Adelaide
Telephone: (08) 226 1000
Facsimile: (08) 226 1234

ED 3/38/57G
WP+373/Admin
Mr. D. Newland
226 1574

(Br) Patrick Cronin
Christian Brothers
103A George Street,
THEBARTON. S.A. 5031

Dear Br. Cronin,

I refer to your letter received 13 November, 1992, in which you seek to involve [redacted] in your science education project.

The Director-General of Education gave you approval to extend your research undertakings on 17 September, 1992. Your proposal falls within the ambit of that endorsement.

I wish you success with your undertakings.

Yours sincerely,

[signature]

Anne Harris
A/MANAGER
ADMINISTRATIVE SERVICES BRANCH
23/11/92

Education Department of South Australia

ED 3/40/45
Mr. D. Newland
226 1574

31 Flinders Street
Adelaide
South Australia 5000
GPO Box 1152 Adelaide
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Br. Patrick Cronin
Christian Brothers
103A George Street,
THEBARTON, S.A. 5031

March 16, 1993

Dear Br. Cronin,

I refer to your letter of 11 March, 1993, in which you seek to extend your research project into the scientific literacy of Year 11 Physics students.

Your request falls within the provinces of your original application which was approved by the Director-General of Education. Accordingly, I am happy to grant the extension you require and wish you well with your project.

Yours sincerely,

Anne Harris
A/Manager, Administrative Services Branch

Appendix 5.6a

Writing Based Literacy Assessment (WBLA)

This assessment scheme, pages 97 and 98, is the one used officially by group moderators to assess whether pieces of writing are satisfactory for WBLA or returned to the students. The assessment scheme sets the foundational level for coherence and fluency.

Appendix 5.6b

Adapted version of WBLA

This scheme, page 99, was the first attempt to assess physics expression and content at levels above that of the foundational level of WBLA. The first essay, page 100, was written before the use of SLDP and the second essay, pages 101 and 102, was written after the use of SLDP. The marking scheme shows an increase in marks from $1^1/_2$ to $4^1/_2$.

CRITERION FOR ASSESSING THE WRITING

The main criterion for assessment is that a submitted piece of writing is fluent, and makes sense as a whole, considering the purpose for which it was written. Students must show that they have the following features under sufficient control to achieve that end, as demonstrated in the exemplars.

FRAMEWORK FOR PROVIDING FEEDBACK TO STUDENTS

	COMPOSING	PRESENTING
	In relation to organisation of ideas	
In the writing they submit, students should aim to show that they can:	• structure a piece of writing coherently (i.e. relate ideas to one another logically from sentence to sentence and paragraph to paragraph); • write in a form appropriate to the task; • provide the information needed for particular kinds of texts, their purposes, and audience.	• identify paragraphs where the text requires them; • use formats correctly.
	In relation to construction of sentences	
In the writing they submit, students should aim to show that they can:	• keep control of the syntax in writing sentences; • use the correct forms of verbs (e.g. in subject-verb agreement); • use tenses consistently.	• use the conventions of punctuation.
	In relation to vocabulary and expression	
In the writing they submit, students should aim to show that they can:	• use a wide range of words; • use words and phrases accurately (in terms of meaning); • use subject-specific language accurately and appropriately; • adopt a formal or informal style as appropriate to the task.	• spell commonly used words correctly.

The Appendix contains a more detailed version of these criteria. Assessors may wish to consult this in preparing precise comments for students who do not meet the requirements of this assessment.

SSABSA

SENIOR SECONDARY ASSESSMENT BOARD OF SOUTH AUSTRALIA

THE SACE WRITING-BASED LITERACY ASSESSMENT STUDENT FOLIO

NAME	
SCHOOL	
CLASS/GROUP	CANDIDATE NUMBER

FIRST SUBMISSION Date:

Categories	Subject	Stage	Cont. Prose	S/RNM
1: English or English as a Second Language.			yes/no	
2: Arts/humanities/social and cultural studies at Stage 1 OR language-rich at Stage 2.			yes/no	
3: Mathematics/science/technology at Stage 1 OR quantitative/experimental at Stage 2.			yes/no	
4: Any area of study.			yes/no	
Assessor's Signature:				
Moderator's Signature: (if appropriate)				

RESUBMISSION 1 Date:

Categories	Subject	Stage	Cont. Prose	S/RNM
1: English or English as a Second Language.			yes/no	
2: Arts/humanities/social and cultural studies at Stage 1 OR language-rich at Stage 2.			yes/no	
3: Mathematics/science/technology at Stage 1 OR quantitative/experimental at Stage 2.			yes/no	
4: Any area of study.			yes/no	
Assessor's Signature:				
Moderator's Signature: (if appropriate)				

RESUBMISSION 2 Date:

Categories	Subject	Stage	Cont. Prose	S/RNM
1: English or English as a Second Language.			yes/no	
2: Arts/humanities/social and cultural studies at Stage 1 OR language-rich at Stage 2.			yes/no	
3: Mathematics/science/technology at Stage 1 OR quantitative/experimental at Stage 2.			yes/no	
4: Any area of study.			yes/no	
Assessor's Signature:				
Moderator's Signature: (if appropriate)				

RESUBMISSION 3 Date:

Categories	Subject	Stage	Cont. Prose	S/RNM
1: English or English as a Second Language.			yes/no	
2: Arts/humanities/social and cultural studies at Stage 1 OR language-rich at Stage 2.			yes/no	
3: Mathematics/science/technology at Stage 1 OR quantitative/experimental at Stage 2.			yes/no	
4: Any area of study.			yes/no	
Assessor's Signature:				
Moderator's Signature: (if appropriate)				

EXTENDED WRITING TASK FEEDBACK TO STUDENTS

NAME:	FIRST WRITING	SECONDWRITING
COHERENCE:	—	✓
order of concepts for explanation	✓	
narrative order		
sequence of procedure		✓
paragraphing	2	4
Introduction and conclusion	—	✓
PHYSICS KNOWLEDGE:	1 or 2	6
Items from correct Ideas	1	—
Items from Incorrect Ideas	—	yes.
references to Laws, scientists etc		
ENGLISH LANGUAGE:	✓	✓
sentence construction		✓
use of connectives	✓	✓
vocabulary, spelling etc	×	— good length
~~format~~ style, title, length etc	not good for the patient.	interesting
TOTAL	~~1~~ 1/4	4/12 4/16 · 4/4
	1½/6	4½/6 · 5½/6

①

7/10

"You, as a radiotherapist have to tell a patient that she is to undergo radiotherapy treatment. Explain as much as you can about the procedures."

To treat your particular disease radiotherapy treatment is needed. The treatment comes in a form of x-rays or other forms of radiation. Cancer patients are often treated with radiotherapy and hair loss and nausea results.

Radiotherapy is accomplished by heat transmissi and the energy is transported by waves. Radiation comes in two forms, heat radiation and atomic radiation. ~~Radiation~~ Radiotherapy treatment is atomic radiation. Using radiation rays such as gamma and beta rays, the infected cells are killed, therefore halting the disease.

(2)

1

EXPLAIN THE MEDICAL APPLICATION OF RADIOACTIVE SUBSTANCES.

good intro Radioactive substances are very important medica[l] tools. Techniques such as PET, radioactive tracer, CAT, and x-rays are being used increasingly in today's scientific world.

PET is one of the medical techniques used in hospitals. They introduce gamma (γ) particles (rays) into the specific part of the patients body which they wish to photogra[ph]. The gamma particles release beta (β) and positron (the opposite of beta) particles, (whi[ch]) make it posible for the photograph to be taken. The Beta and positron particle are not very dangereus because they have a very short half-life (barely a few seconds). Half-life is a measure of the rate of radioactive decay. *excellent*

X-rays, discovered in 1845 by a German physicist are a kind of electro-magnetic radiation. (It) *you mean the EMR radiation* includes visible light, radio waves and gamma rays. Positrons collide with an electron in the atomi[c] orbits on the way out, (thus) annihilating and so producing the X-ray. X-rays can cause biological, chemical and physica[l] changes in substance. If the rays are absorbed by a plant or animal they may damage or even destroy living tissue. In humans, an overdose of X-ray may produce cancer, skin burns, a reduction of the blood supply or oth[er] serious conditions. Lead aprons are used to protect both the physicians and the patients from the bulk of the rays.

Catscans are in some ways similar to x-rays. The rays (particles) can be channelled to any area of the patients body. The rays can go under, around or even give a cross-section of a part of the body. The physician look at the crosssections of their patients' body through a computer screen.

Various radioisotopes or radioactively labelled compounds may be introduced into the human body. This is a medical diagnostic application called the radioisotope tracer analysis. Different radioisotope tracers are used for different parts of the body. For example, in the lungs, ~~can be~~ carbon-11 or oxygen-15 are a few of the common tracers used. The actual amount of tracer introduced must be very small that the system being investigated does not change it's working functions.

The application of radioactive substances is incredibly useful in the diagnostic medical field.

Good conclusion

Appendix 5.7a

Pilot study post-SLDP student survey form

The questionnaire in this appendix was used to survey the effectiveness of SLDP from the responses given by students after they had used it.

Appendix 5.7b

Pilot study post-SLDP teacher survey form

The questionnaire in this appendix was used to survey the effectiveness of SLDP from the responses given by teachers after they had used it.

SLDP STUDENT SURVEY

1. Number these places: 1st, 2nd, 3rd, for the ease of writing an essay in each subject:

Hist/Geog/Econs 2nd

English 1st

Physics 3rd

2. Why did you put Physics in the order that you did?

because find it hard to associate theorys to practicals, I can't remember all [illegible]

3. Do you think that writing about a Physics topic such as magnetics, radiation, heat, electricity helps you to understand it better? (tick one)

__ __ ✓ __ __
no help some help great help

4. How much have the following techniques helped you in your writing?

(a) Drawing your own concept maps. (tick one)

__ __ __ [crossed out] ✓
no help some help great help

(b) Using the computer to make concept maps (tick one)

__ __ __ ✓ __
no help some help great help

(c) Writing paragraphs with connectives (tick one)

__ __ ✓ __ __
no help some help great help

5. Do think you will use any of these techniques again?

Which ones and why?

yes concept maps because it out lines everything you need to write and [illegible] the order it has to be in.

6. Which "style" do you like to write in the following subjects:

ONE TICK FOR EACH SUBJECT

	English	Physics	Hist/Geog/Econs
*Narrative (with personal ideas)	___	✓	___
*Report (about an activity)	___	___	✓
*Informal explanation (first person present tense)	✓	___	___
*Formal explanation (third person past tense)	___	___	___

7. Do think you will do Physics next year in Year 12? (tick)

YES ___

NO ✓

8. Do you read about Physics ideas from (tick)

	none		some		a lot
(a) books from your school library	✓	___	___	___	___
(b) books from a public library	✓	___	___	___	___
(c) science magazines	✓	___	___	___	___
(d) science in newspapers	✓	___	___	___	___

9. Do watch science shows on TV

	none		some		a lot
(a) "Beyond 2000"	___	✓	[crossed out]	___	___
(b) "Quantum"	✓	___	___	___	___

THANK YOU FOR YOUR HELP

Question 4 (c) paragraph writing?

Comments: More time needed to be spent with grasping concepts before beginning this

Question 5:

If this was to be done in another school, what suggestions would you make?

Comments: Build up the computer assisted part with more practice in class in writing out concept maps. Initially just 3 or 4 levels before starting the more complex

Question 6:

Please comment on any other aspect of the four week trial?

Comments: The four week trial was cut down to three weeks only — which was nowhere near enough to really draw conclusions on the effectiveness of the program. The four week trial should have consisted of simply learning the writing of concept maps that had previously been studied. I was generally impressed with this approach to essay writing and will use this process in other science classes — Year classes going into SACE would find this very helpful. Very impressed with the program itself — well written and fairly user friendly — would be nice to see a 'colour' HyperCard as well as video incorporated into the program.

Appendix 5.8a

An example of one student's first extended writing

This essay was written by the student before the use of SLDP.

Appendix 5.8b

An example of one student's concept map

This is the concept map of the same student, produced using HCP in the SLDP program.

Appendix 5.8c

An example of one student's second extended writing

This is a second piece of writing on the same topic after the use of SLDP.

25

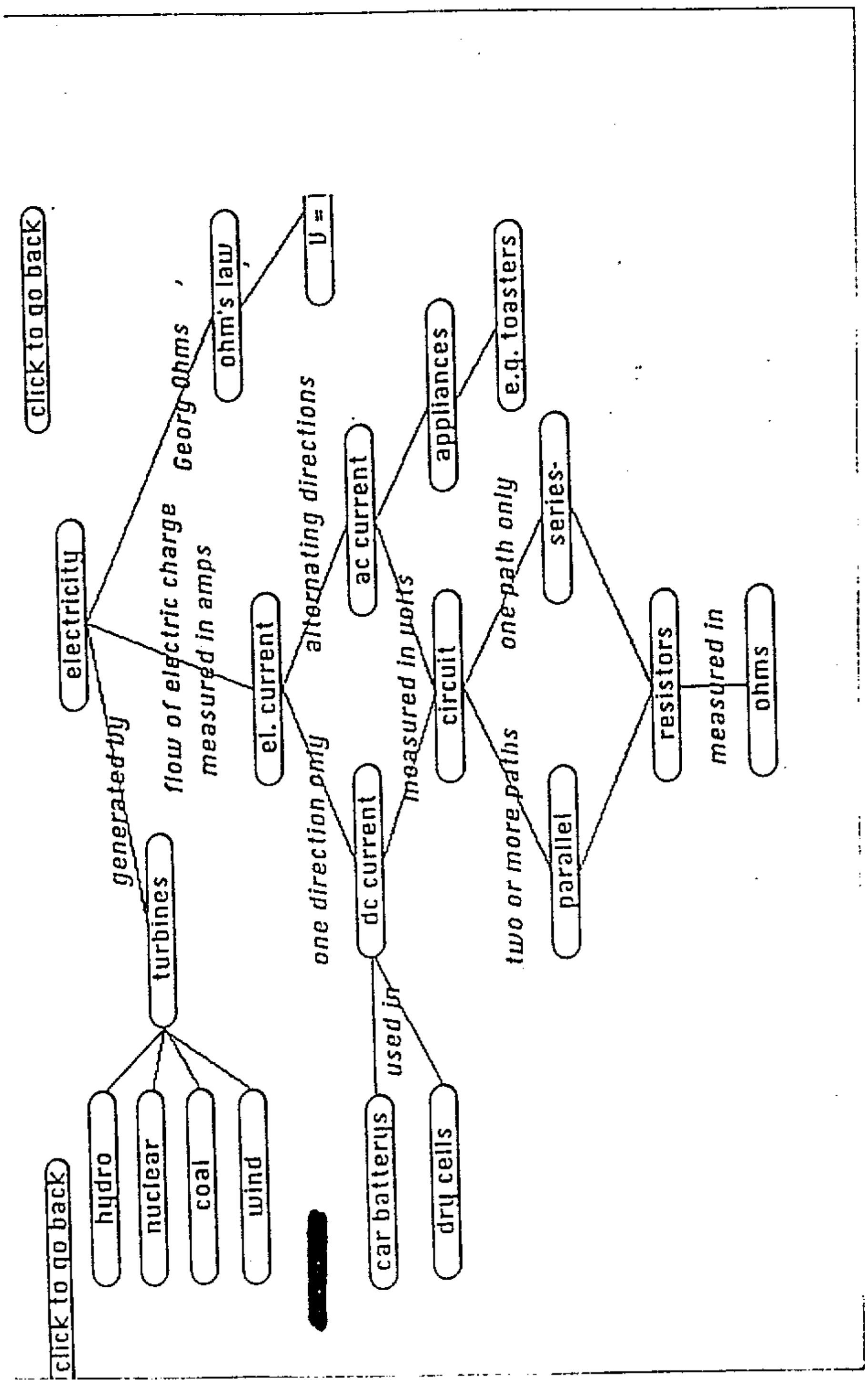
In what way is Electricity and its manufacture to humankind beneficial and in what ways is it harmful. In what ways can it be made more useful and in what ways less harmful.

Electricity is a very important aspect of today life world, electricity is a dividing line between a primitive society and an advanced, modern one. It plays an important role in our everyday life, whether it be turning on a light or using it to develop new machinery etc.

Electricity is used for many different appliances, toasters, televisions, light switches, radios, heaters, etc. It is an important aspect of life; but also a very dangerous one. For example, Putting metal objects in power points has disastrous consequences. Because metals are conductors of electricity so the current would travel along the bit of metal and make contact with the human body, which would result in electrocution. A device which prevents electrocution ~~is now available~~, it is a safety ~~measure~~ switch and its function is to ~~stop~~ ground the electric current in case of an emergency.

Electricity is useful in finding cures for diseases and treating illness. New developments are being made all the time, which are ~~to be~~ important in saving human life. I believe that this is the most important aspect of electrical use, as it is being used for things that really matter. Anything that can save lives is important.

A great disadvantage of electricity however, is in the ~~use of~~ manufacturing of weapons such as missiles, guns, grenades, etc. This is destructive to human life and destruction to our environment.


click to go back
electricity
Georg Ohms
ohm's law
U =
generated by
flow of electric charge
measured in amps
el. current
alternating directions
ac current
appliances
e.g. toasters
turbines
hydro
nuclear
coal
wind
one direction only
dc current
measured in volts
circuit
one path only
series-
two or more paths
parallel
resistors
measured in
ohms
used in
[redacted]
car batterys
dry cells
click to go back

Electricity Essay

A.

To Mr. Michael Faraday,

~~This is a letter from the future to explain how my life is affected by electricity.~~

Electricity is the flow of electrons within a circu to generate energy for the purpose of many luxury applianc and also for beneficial uses such as medical research an scientific research, ultimately for the good of mankind.

Electricity is generated in a power station using methods such as; the ~~he~~ use of coal; ~~he~~ using the heat from nuclear reactions which becomes steam and as a result spins the turbines thus generating electricity; the use of hydroelectric devices and wind. All of these methods reach the same result, spinning the turbines to generate electricity. How they reach this end result ~~vart~~ vary's in each case, however they reach the same conclusion, an that is the purpose.

There are two types of electricity, alternating current (AC) and direct current (DC). Alternating Current h the flow of electrons travelling in two directions whereas direct current has the flow of electrons travelling in one direction only. Direct current is used mainly in cars, i.e. car batteries, and alternating current is used mainly in househould appliances such as lights, ~~and toaster~~ and in machines, s as electric drills.

Alternating current and direct current both take for in circuits. There are two types of circuits, series and parallel. A series circuit has one path only for the flow c electrons, in contrast to a parallel circuit which has mor than one pathway for the flow of electrons. Both series a

parallel circuits contain an electrical voltage source, either direct curre
or alternating current, which is measured in volts, resistors
which is measured in ohms and restricts the flow of electric
charge slightly, and always contains an electric current, wh
is measured in Amps. From this we get Ohm's law, V=IR,
which tells us that the voltage is equal to the product of th
resistance and current.

As a safety device series used in a house, school
etc., contain a device called a fuse ~~so~~ which has the
purpose of blowing, out if there is too much current in a
series. Without a fuse there would be fatal consequences

Electricity plays a vital part in our everyday life. It
has paved the way for breakthroughs in medicine, which
has a direct result on mankind. It is also useful for luxur
conveniences, such as television, microwaves and so on. If
it wasn't for electricity, ~~our it~~ my life would be very
different.

12/12

Appendix 5.9

An example of a student's paragraph writing

The paragraph was written during the SLDP lesson on paragraph structure in the "Nuclear radiation" topic. Paragraph writing illustrates the use of connectives between sentences which are related to one central idea in each paragraph.

Good Paragraphing 20
[redacted]

Radioactivity.

An unbound neutron decays in a proton and an electron. During the radioactive decay alpha and beta particles and high-energy electromagnetic radiation are emitted. The atomic number of an atom or ion refers to its number of protons whereas the atomic mass number of an atom refers to its number of nucleons.

If a radioactive material has a half-life of 1 year then there will be one-eighth left at the end of three years. When uranium (92 proton ejects an alpha particle, the nucleus has 90 protons whereas if thorium (90 protons) ejects a beta particle then, the nucleus is left with 91 protons because it has lost a neutron but gained an electron. All elements beyond uranium in the periodic table have relatively short half-lifes. Carbon 14 is radioactive and decays into nitrogen 14. The half-life a carbon-14 is 5730 years and if a bowl contains one-half as much as carbon 14 as a new bowl of same material has a half-life of 1932 years.

Excellent 6/6

Appendix 6.1
Teachers' Manual

The Teacher's Manual was developed in response to the recommendations of the pilot study. The version used in the first extended study was subsequently refined into this version which is the one used in the second extended study. It has its own table of contents on page 117.

SCIENTIFIC LITERACY DEVELOPMENT PLAN (SLDP)

TEACHERS' MANUAL

This manual is written for the Scientific Literacy Development Plan (SLDP) incorporaying a number of HyperCard Physics (HCP) computer programs with accompanying lesson packs in a number of Physics topics

- HCPelectricity
- HCPheat
- HCPmagnetics
- HCPradioactivity
- HCPdynamics
- HCPelectromagSpec
- HCPlight
- HCPsound
- HCPyear12

This draft version is to be trialed by a number of schools in South Australia in first semester 1993.

Programming assistance from Gary Williams of the University of Western Australia was gratefully accepted.

Patrick Cronin
Science & Mathematics Education Centre
Curtin University of Technology,
Perth, Western Australia.

CONTENTS

INTRODUCTION

PURPOSE

The SLDP is a plan to increase the scientific literacy of senior secondary science students. This manual is written for teachers of Physics students, but it can be adapted for use with other science syllabi.

The SLDP is partly designed to meet the Domain 4 objectives of the Extended Subject Framework for Physics (Senior Secondary Assessment Board of South Australia, 1991) so that students should be able to:

> 4.1 develop their scientific literacy and in particular their use of Physics terminology and notation;
> 4.2 develop a variety of communication skills in situations which use Physics;
> 4.3 use their creativity and/or imagination to communicate about Physics or Physics related issues (p.12).

The Extended Subject Framework provides examples of activities designed to enhance scientific literacy according to the above descriptors. The SLDP offers further assistance for the achievement of these objectives. The SLDP also offers teachers a systematic program to develop student writing skills, along with other skills, for the purpose of meeting the Writing Based Literacy Assessment (WBLA) requirement at Stage 1 (Senior Secondary Assessment Board of South Australia, 1990) and as preparation for the Stage 2 Essay Question of the Public Examination Subject (PES) Physics Examination. Further HCP programs are being developed for Chemistry and Biology.

DEFINITION

While the Extended Subject Framework for Physics provides objectives and suggestions for learning activities plus a number of

While the South Australian Certificate of Education documents provide a framework of objectives and suggestions for learning activities plus a number of exemplars, they do not provide a theoretical base for a definition of scientific literacy. Based on extensive literature research, such a definition is proposed as follows:

> **Scientific literacy is the human activity of assimilating scientific conceptual relationships** (after the work by Vygotsky)----
> **into personal cognitive structures** (after the work of Ausubel and Novak)---
> **and communicating these conceptual relationships and critical analyses of scientific issues** (after the work of Halliday)---
> **through the language register of science** (after the work of Lemke).

This definition indicates there are four dimensions in which developmental activities are required.

1. Vygotsky (Cole et al, 1978) proposed that there were development pathways of two types of concepts. The scientific concepts were created verbally and in some abstract definitional form while the spontaneous concepts had no such systematicity and grew from contextual associations. Although the two processes assisted each other in development, Vygotsky found there was a time lag of written language behind spoken language, due to factors such as replacement of sensory images with the symbolisation of images, the requirement for a different syntax in written language, and the non-interactive nature of written communication.

> To summarise, the most essential feature of our hypothesis is the notion that developmental processes do not coincide with learning processes. Rather the developmental process lags behind the learning process; this process results in zones of proximal development. Our analysis alters the traditional view that at the moment a child assimilates the meaning of a word, or masters an operation such as addition or written language, her developmental processes are basically completed. In fact they have only just begun at that moment. The major consequence of analysing the educational process in this manner is to show that the initial mastery of, for example, the four arithmetic

> operations provides the basis for the subsequent development of a variety of highly complex internal processes in children's thinking (P.90)

2. The theory about the development of conceptual relationships of science comes from the work of Ausubel(1963) and popularised by Novak (1977):

> When science is recognised as a framework of evolving concepts and contingent methods for gaining new knowledge, we see the very human character of science, for it is creative individuals operating from the totality of their experiences who enlarge and modify the conceptual framework of science. (P.20)
>
> Even the term cognitive structure has special meaning for Ausubel. He views the storage of information in the brain as highly organised, with linkages formed between various older and newer elements leading to a conceptual hierarchy in which the minor elements of knowledge are linked with (subsumed under) larger, more general, more inclusive concepts. (P.25)

3. Critical analyses are developed within the total "field", "tenor" and "mode" of communication according to the well developed socio-semiotic theory of Halliday (1978)and Halliday and Hassan (1985) . They preferred to state that knowledge was transmitted through social contexts and that relationships like those of parent to child or teacher to pupil or peer to peer, were pre-eminent in establishing language patterns. Their studies found that the language used in these contexts derived its meaning from the activities in which it was embedded. Cultural and social values were also transmitted and education was needed to provide a means for critical analysis.

4 A special language register (for science in this case) is defined in the Longman Dictionary of Applied Linguistics (Richards et al, 1985) as:

> The term used for the varieties of language used by specialists in writing about their subject matter, such as the language used in botany, law, nuclear physics or linguistics. The study of special languages includes the study of terminology (the special lexeme used in particular disciplines) and the register, the distinctive features which occur in special languages. (p264)

The language register of science is a system of technical terms, codes, equations and symbols as well as containing a specialised vocabulary. It has a characteristic syntax of causal, sequential and definitional phrases, clauses and sentences to express relationships between concepts. It employs diagrammatical, mathematical and specialised nomenclatures. Lemke (1982) describes the register as follows:

> The register of correct and serious science discourse--- should be explicit and verbal (versus gestural and non-verbal), fully lexicalised (except for spoken symbols), minimally elliptic and expressed in the form of propositions which are to be interpreted independent of the situational context of utterance and should be non-tautologous and prime facie of universal validity. It should exhibit the features of written English where these differ from colloquial: in lexical choice and semantic structures, without colloquial markers ('like', 'gotta' etc] and personal pronouns (especially first and second person). In all these respects the register is defined by contrast with 'common parlance' colloquial language. (p261)

The SLDP is designed to meet these four dimensions in the definition of scientific literacy:

- concept mapping provides the advance organiser for assimilation of conceptual relationships into the cognitive structure;
- working through the HCP program allows for informal oral communication between students and teacher;
- the use of a language register in conventional English is provided in the classroom lessons of SLDP;
- the writing tasks require a specific genre of writing and a focus is provided on the two genres *explanation* and *argument* by illustrating models of writing and an assessment scheme for the *explanation* genre. The *argument* genre is best suited for the development of critical analysis of scientific issues.

Thus the SLDP provides the practical means of incorporating the four dimensions of the definition of scientific literacy and the specific objectives of Domain 4 of the Extended Subject Frameworks.

FEATURES OF SLDP

The features of the SLDP are:
1. It is a **flexible** system of lesson plans that can be integrated into any of the exemplars currently produced for SACE. It is based upon being able to develop scientific literacy within any particular content module.

2. It incorporates **concept mapping** as process for developing the conceptual relationships of science with appropriate language links between prior knowledge, new concepts and personal creative expression.

3. It incorporates a **computer package** HyperCard Physics (HCP) that speeds up the process of concept mapping, provides reading texts using modern vocabulary, models of extended writing and an assessment scheme. The use of computers is also intrinsically motivating to most students.

4. It provides **reading texts** about current applications of Physics with a current vocabulary as well as issues for critical analysis.

5 The Hyper Card Physics program is **dynamic** in that students and teachers with some familiarity with HyperCard, can adapt and add reading texts and models of extended writing to suit their own particular topics.

THE ELEMENTS OF SLDP

1. CONCEPT MAPPING
Approximately two lessons can be given to pen and paper exercises for: concept vocabulary, hierarchy, links, branching, and relational statements. This is a classroom activity. Alternatively this can be done on 'data show' overhead projector.

2. COMPUTER ASSISTED CONCEPT MAPPING
This program, called HyperCard Physics (HCP), consists of Hyper Card stacks in concept mapping, reading texts, and writing models. The user can move through cards in any direction and between stacks. A total of six lesson times is required.

3. ELEMENTARY SENTENCE CONSTRUCTION
This may need only an introductory part of one lesson depending on the knowledge and ability of the students. Normally a wide range of ability is found here and further remedial assistance will be required by some. The SVO (subject-verb-object) structure needs to be taught and the place of qualifying phrases and clauses shown to students.

4. PARAGRAPH WRITING
This is planned for one lesson but the activities can be used more frequently with great effect. Four types of paragraphs are introduced:

- Definition
- Description
- Comparison & Contrast
- Sequence & Consequence

with the use of appropriate language forms and connectives such as FANBOYS links (Bailey,1990). This is in accord with the work of Gardner (1977, 1978). Paragraphs can be written from the concept development exercises such as those by Hewitt, (1987) as well as composed form multiple choice tests

5. COMPUTER ASSISTED READING TEXTS

These are short texts selected from current science magazines. The concepts in bold are "click-chunked" for the students to select for their concept maps. The texts are about contemporary events and projects and contain "new" vocabulary. Students make links between the new concepts and prior concepts in the topic. No extra classroom lessons are needed here.

6. LANGUAGE REGISTER OF SCIENCE

A summary of genre and language styles can be given to the students in the HyperCard Physics program and also as hand-out sheets. Two language styles for each topic are modelled in the HCP program. The reading texts in the program also give a variety of genre and language styles. A part of one classroom lesson may be sufficient, but follow-up work after assessment of the extended writing tasks will need to be done with the students.

7. EXTENDED WRITING TASKS

Normally two lessons are required for each writing task. The writing task can be set as an assignment for formative or summative assessment or set as a "teacher supervised" task for inclusion in the WBLA folio. One extended writing task is required in the SLDP for each Physics topic in preparation for the Essay question of Stage 2 PES. There is provision for word processing of the extended writing task in the HCP program. The writing tasks can be used to gauge student improvement. A number of marking schemes can be used including the WBLA exemplar scheme. However, the one recommended in this plan is more comprehensive. It includes Physics knowledge and the cognitive relational aspects of that knowledge over and above the language skills. The SLDP marking schemes are based on the scheme developed by Biggs and Collis (1982) and are called the Scientific Explanation Genre Assessment Scheme (SEGAS) and the Scientific Argument Assessment Genre Scheme (SAGAS).

8. ASSESSMENT AND REVIEW

Normally one lesson will generally be needed to review the writing and concept maps of the students. Feedback to the students according to SEGAS or SAGAS is most valuable.

CONCLUSION

Initially, the total number of lessons required for the first topic will be approximately 12 lessons: six in the computer room and six in the classroom. This number of lessons can be reduced to four in the computer room once the students have understood concept mapping. This can further be reduced to two HCP lessons for further essays.

In Year 12 only two lessons for each topic are required: one for the reading texts and concept mapping and one for the extended writing task. The value of the SLDP will best be realised if it is done in each topic of Year 11 and Year 12 if possible.

Elementary sentence construction and paragraph writing will always need to be done as incidental to normal classroom teaching but they need not take up whole lessons apart from the students requiring special remedial assistance.

The results ofpilot studies in 1991 and 1992 indicate an approximate 20% improvement in the writing skills of Physics over and above the normal improvement. The pilot study also indicated a positive student opinion to writing through the SLDP.

IMPLEMENTATION

Results of trials in this research project indicate that a large improvement in scientific writing occurred when a series of 12 lessons was given initially. Later applications of SLDP can be interspersed among normal lessons as required. The plan for the initial implementation of SLDP is as follows:

CLASSROOM	COMPUTER ROOM
L-1 Concept mapping L-2 Concept mapping	
	L-3 HCP Concept mapping L-4 HCP Concept mapping
L-5 Elementary Sentence Const L-6 Paragraph Writing	
	L-7 HCP Reading texts L-8 HCP Writing task
L-9 Language register of science	
	L-10 HCP typing L-11 HCP typing
L-12 Assessment review	

After the students have been through the program once, four computer lessons would suffice for following topics and then eventually be reduced to just two lessons: one for concept mapping and reading texts and one for the extended writing and typing.

MATERIALS & REQUIREMENTS

It is advisable for the teacher to work through the whole HyperCard Physics (HCP) program first before implementing it in the classroom. The teacher should also "book" the computer room for at least six lessons within each topic, preferable towards the end of teaching a particular topic. The HCP programs are:

1. HyperCard Physics programs have been written for:
    - HCPmagnetics
    - HCPheat energy
    - HCPradioactivity
    - HCPelectricity
    - HCPsound
    - HCPlight
    - HCPelectromagnetic spectrum
    - HCPdynamics
    - HCPyear12

Each program consists of three 'stacks': After opening HCP, the 'commence" stack is the only one visible on screen. After opening this, a 'commence card' is linked to the first stack. This stack contains 19 cards of training and practice in concept mapping. Then follows a further 10 cards of reading texts in which certain concepts have been 'click chunked' for selection by the students for their essay concept map. Then follows a further 16 cards of training and practice in writing. The essay concept map is in a separate stack and this contains eight cards for a possible eight different concept maps in that particular topic. The essay concept map can be accessed directly from any of the reading and writing cards by means of a customised button. This means that the students are encouraged to use a concept map as a summary device for their reading and as a scaffolding device for their writing. Concept mapping enables students to assimilate new knowledge into prior knowledge in the personal cognitive structure which is continually enhanced and refined.

2. The HCP programs require a network of Macintosh machines with 2 mb RAM and sufficient storage memory. A rapid linking system such as "digicard" is also required.

3. It is advisable for students to have their own floppy discs on which they can store their personalised stacks essay concept maps and typed essays. In this way they can build up a complete summary of their whole Physics course.

4. Ready access to a printer is necessary for printing concept maps (PRINT CARD) and essays (PRINT FIELD).

5. This Teachers' Manual contains simple instructions for the teacher unfamiliar with HyperCard, as well as more advanced directions for teachers who are more familiar with HyperCard to customise new reading cards (and delete those not required) for their own purposes. It is anticipated that HCP will become a dynamic program so that new cards be added as reports of up-to-date projects and events come to hand. The sources of these new reading texts can be found from magazines such as New Scientist, Genesis, Discover, The Physics Teacher, The Science Teacher, Scientific American, The Australian (Wednesday) Supplement etc.

6. Initially students may need a large piece of paper for concept mapping in the first lesson. A 'data show' overhead projector is an advantage in illustrating the program.

L-1&2. CONCEPT MAPPING

OVERVIEW FOR THE TEACHER

The first lesson is devoted to introducing SLDP as an integrated package of concept mapping, genre writing in a scientific language register, reading of scientific texts, explanation and discursive essay models and writing/typing of personal essays.

The second lesson can be devoted to teaching the technique of concept mapping. This can be done with pencil and paper, overhead projector transparencies or data show overhead projector. Similar charts to concept maps are flow charts, semantic networks, classification tables etc. The elements of concept mapping used here are from the work of Novak & Gowin (1984). The elements are:

- concepts ...words or phrases that contain a single idea
- hierarchy... levels of order usually from concrete to abstract or specific to general
- links... line connections between concepts that are related
- branching points...where subsumation takes place
- relational statements...connecting words and phrases which can be simple English connectives or connectives of technical language

The quality of the concept map can be judged by the use of the above features, and there is no one "correct" concept map. Although there are a number of ways that scientific relationships can be expressed, there are also misconceptions that can be corrected during the construction stage. A scoring method for concept maps is supplied in Appendix A, but it is best not given to students who may manipulate the map for points rather than create scientific relationships within their own cognitive structure.

Concept mapping prepares students for the writing task and incorporates much oral discussion during the construction phase.

The teacher has the opportunity to assist students in the creation of relational statements in completing the concept maps.

LESSON 1

Use the SLDP LESSON PACK of overhead projector transparencies or a Macintosh data show overhead projector to introduce the first 6 cards of the HCP program. Introduce this series of 12 lessons in computer assisted learning for this particular topic Explain to the students that it will help with learning Physics knowledge as well as assist them with extended writing tasks. Its main purpose is to develop scientific literacy skills including reading comprehension and writing skills.

First, students open the HCP program by double clicking on the various icons until the 'commence' card is reached. This indicates the Physics topic being studied. See the first transparency.

CARD 1
The 'buttons' on card 1 are for easy navigation around HCP. Clicking on any button takes the user to sections. The number in the top right hand corner indicates which card the user is at any time. The 'return arrow' at the top left hand corner can be used to return to card 1 at any time.

When using the data show, click over to the READING TEXTS to show the type of modern day applications that involve knowledge of this Physics topic. Just click through the sequence of 10 cards quickly reading out the caption for each. Return to card 1 via the return arrow (top left hand corner). If using transparencies, find the reading text overview in L-7&8.

Use the transparencies for L-10&11 or click the WRITING TEXTS button, if using a data show, to see how there will be two model essays to observe and a number of blank cards for the students' own work. Explain that the essay title will be set when L-10 is reached.

Now go back to BEGIN HERE to commence the HCP program.

Pause for questions

CARD 2

The HCP program is written in a special computer language. It allows each student to proceed at his/her own rate. Each student will have an individual disc on which individual work is automatically saved. It may be taken up at the end of each lesson.

The program consists of a number of Physics topics. Each student is encouraged to find reading texts and resources for themselves.

Pause for their answers and further questions.

CARD 3
The three decisions for a writing task are illustrated on screen. There is no need to go into a big discussion here as more will be done later. Explain simply:

-**Genre** means the type of writing task required. There are examples of model essays genres in the writing task section.
-**Language Register** is the style the individual writer chooses in which to write.
-**Concepts** are the Physics ideas required in the extended writing task.

Pause for questions

CARD 4
The six genres are illustrated. Go through each one giving an example for each that students would have encountered in previous classes.

Ask the students for their own memories of required writing tasks.

Pause for their answers and further questions.

CARD 5
The various aspects of the Language Register are illustrated on screen. Explain each.

Have the students write sentences in some of these aspects, eg first person past tense recount. or a third person past tense formal report etc. Two or three sentences will be sufficient to make the point.

Pause for their answers and further questions. Some further sentences may be set for homework at the end of the lesson.

CARD 6
Introduce the idea of mountaineering as an example of concept mapping. People at the top of a mountain have a more general view than those at the bottom. Other useful examples are classification schemes in geology or biology. The concept of Australia can be thought of geographically, anthropologically or in social terms. Concept mapping can be used in all of these contexts. It is introduced for Physics in the next lesson.
END OF THE LESSON (L-1)

LESSON 2

Begin the introduction to concept mapping by using the mountaineering model. Use the transparencies or data show to proceed through cards 7 to 19. The students will be making their own concept maps on computer in the next two lessons (L-3&4).

CARD 7
This shows two features of mountains, levels and tracks similar to concepts and relational statements in concept mapping.

CARD 8
This is typing the names of levels in the boxes provided. This shows the way in which the mountain is scaled similar to naming the Physics concepts used in writing an essay.

CARD 9
This indicates the four levels of knowledge about a topic:

- **theories** which seem to explain most of the knowledge we have but are sometimes changed
- **abstract** concepts which bring together a number of concepts but cannot be measured
- **general** concepts which apply to a number of the observed things Usually measurements, units and rules.
- **observed** things and events with their particular properties.

CARD 10
This is an example of the concept map for "the Universe".

CARD 11
Students now have to arrange their own concept maps of the listed concepts from marine biology.

CARD 12
The answer to card 11. Don't show too much of this as the students will be doing this exercise on computer in the next two lessons.

CARD 13
This card introduces the list of concepts in the particular topic. Definitions of each topic can be found by holding the mouse 'stillDown' on each definition button. Students can return to this card whenever they need to see the definitions again.

CARD 14
Now the students begin concept mapping with just two skills, select concepts and draw lines:

- Select the mapping menu and drag down to the menu item 'list of concept'. This then becomes a menu.
- Drag down under list of concepts to select any concept required for the concept map.
- Move this concept around by clicking in the middle of the concept.
- Select a number of concepts and move them into a concept map which has the structure of theory, abstract, general and observed things as illustrated previously.
- Select 'line' tool under the menu 'mapping' in order to connect the concepts up with lines.
- To get out of 'line' the students will need to select 'finished drawing lines' under 'mapping'. They often forget to do this when they first start and hence cannot progress any further.

- Concepts can be removed by selecting 'erase concept' under menu 'mapping'.
- Lines can be erased under menu 'mapping'. Students will need to get out of this tool be selecting 'finished erasing line' under 'mapping'. They often forget to do this when they first start.

CARD 15
The students are now introduced to relational statements that connect concepts. It is a read only card

CARD 16
This card shows three types of relational statements: verb phrases, connectives and Physics rules. Students will have the chance to use all three in the next few cards. This is a read only card.

CARD 17
This card gives an example of how the relational statements are used on the connecting lines.

CARD 18
This card allows the students to select relational statements:

- Under the menu 'mapping' select 'list of relational statements'
- Under the new menu 'relational statements' select any required word.
- Place the relational statement where required on the concept map.
- Relational statements can be removed by 'erase relational statement' under 'mapping'.
- Students can return to definitions if required by clicking on the 'definitions' button.

CARD 19
The two new skills on this card are to use 'new concept' and 'new relationship'. These are both under the menu 'mapping'. Students can now make up their own concept maps by using the provided

concepts and relational statements as well as typing in their own. This is the end of the training in concept mapping.

Transparencies show the result of CARD 19 which can be used to illustrate the skills of concept mapping. This introduction with transparencies or data show, will serve as a guide to students and facilitate their use of the HCP program, although the students will probably need assistance in completing the cards 1 to 19 on the computer.

END OF LESSON 2

L-3&4. COMPUTER ASSISTED CONCEPT MAPPING

This program, HyperCard Physics, is written on HyperCard version 2.1 and will run on System 7 or system 6.7 networks. The program is totally driven by menu items with mouse and must be set at User Level 3. Some elementary skills are required by the teacher such as:

- how to start up the computer system
- how to install HyperCard Physics on the network hard disc
- how to make multiple copies of HyperCard Physics onto work stations or student floppy discs
- how to select and open HyperCard Physics from the disc
- how to select a menu item
- how to select PRINT under menu FILE
- it is not necessary to SAVE in HyperCard. It is automatic.
- how to QUIT under menu item FILE or COMMAND Q
- how to eject the disc by dragging to TRASH
- how to print with a laser printer
- how to close the file and shut down

The elementary skills required by the students are:

- how to select and open HyperCard Physics
- how to select a menu item
- how to use the mouse
- how to type
- how to QUIT under menu item FILE
- how to eject the disc by dragging to TRASH

Two lessons are required for students to complete the first section in concept mapping cards 1 to 19. The steps for student instruction are as follows.

Step 1.

Explain that the cards for concept mapping follow the same pattern as the classroom lesson, L-2. This time they will type in their own responses.

Step 1
First, select and open HyperCard Physics (HCP) under its topic name eg HCPelectricity. Wait.

Step 2
Double click on the "HCPcommence" icon. Wait.

Step 3
When the button "commence" appears, click once. Wait.

Step 4
The program cards have their own directions from now on. From cards 14 to 19 all concepts and relational statements are supplied under the menu 'mapping' which contains 'list of concepts' and 'list of relational statements'. Card 19 allows students to make their own concepts and relational statements by selecting ';new concept' and 'new relational statement' under 'mapping'.

From now on assist the students with their concept mapping tasks. If students enter the incorrect menu items a "cancel" box will appear on screen. Click this once to get back on track. If bigger problems occur, go back to the start by FILE and QUIT and begin with steps 1 to 4 again.

Initially the students will have problems deciding at what level the various concepts should be placed. Keep reminding them about general theoretical concepts at the top and specific measurable and observable concepts at the bottom.

When the students come to relational statements, keep reminding them of the TOP DOWN or BOTTOM UP consistency. This will stand them in good stead for coherent writing in their later extended writing tasks.

It is better not to let the students proceed beyond card 19 yet. Card 19 will occupy the quicker students until all have caught up.

Some examples of student concept maps are contained on transparencies. They are somewhat limited at this stage. Normally the student maps are not printed at this stage, but that are automatically saved on their disc for later use. A concept map scoring scheme is in Appendix A, but this is for teacher use rather than for the students.

L-5. ELEMENTARY SENTENCE CONSTRUCTION

The third element of SLDP, consists of part of one lesson on elementary sentence construction: Subject, Verb, Object (SVO) for transitive verbs and Subject, Verb, Phrase (SVP) for intransitive verbs. Phrases and clauses can be inserted between the S-V-O/P and separated by commas. Whole sentences begin with capital letters and end with full stops. Consistency of use with the tense of the verbs, 1st, 2nd, 3rd person pronouns, singular and plural number must be maintained in a sentence, paragraph or essay. More advanced grammatical forms such as voice and mood can be left till later.

The lesson plan steps could go as follows:

Step 1:

Give some definitions:

Verb: a doing or being word,eg: cause, create, transform, is

Subject: The initiator of the action of the verb, eg: heat causes...

Object: The receiver of the action of the verb, eg: Charge causes an electric field.

Transitive verb: when an action goes directly to the object, eg: Heat causes expansion.

Intransitive verb: when there is no direct object after the verb, eg: Parallel and series circuits can be connected.

Phrase: a group of words without a verb, eg: The air conditioner in our car draws a heavy current.

Step 2

Give students an exercise to rewrite a jumble of words into sentences. Eg: rewrite the following:

the Electricity and its manufacture beneficial to humankind due to the electricity product the lights and power for daily.

The harmful nature of electricity with humankind that was

Electricity is very darange fro to use different kind of electricity or

conect a wrong, charges to each other wire that may be killed
because when we conect the wrong charge or same charge on one
line that will not conect and it will repell

Step 3

Further remedial work in elementary sentence construction may be needed by a number of students particularly for ESL students. Research indictes that at least 20% of students will need this sort of assistance with elementary grammar.

These steps need not take a whole lesson, but a careful explanation of elementary sentence construction may save much time in later correction of student writing.

Elementary sentence construction exercises are contained on transparencies in the **HCP Lesson Pack**

L-6. PARAGRAPH WRITING

There are four types of paragraphs that are commonly used in science writing. They are definition; description; comparison and contrast; sequence and consequence; They can be taught in steps as follows:

Step 1 Definition

Many expository type essays need to begin with a definition. A definition has four parts:

Parts of definition	Example 1	Example 2
1. The item	Fish are	Induced EMF is
2. class in which it belongs	marine animals	a potential difference
3. distinguishing features	with gills & fins	caused by a changing magnetic field
4. uses or operation	to move and live in water	and is measured in volts

Students can write similar definitions for concepts such as electromagnet, alpha particle, hyperthermia, direct current. These definitions can then easily be expanded to form three to four sentences which will make a paragraph.

Step 2 Descriptive paragraphs

These paragraphs are usually related closely to the definition. They take each part of the definition as sub-topics and follow the same sequence as the definition. The sentences contain descriptive adjectives and adverbs. Verbs are used to express classification and description of purpose. An example is:

> An example of experimentation is the use of dummies in car crashes that have been used to

reduce the tragically high road toll. The extent of car damage was matched by the severity of injury to the people in the car. Doctors also found that in real crashes seat-belts drastically reduced the number of serious injuries, particularly those to head and chest.

Step 3. Comparison & Contrast

The connectives used in these types of paragraphs are:

comparison	contrast
similar to...	whereas...
resembles...	unlike...
in the same way...	in contrast to...
just as...	differs from...
in common with...	distinctive from..
both...	although one

Students could be given practice at comparing & contrasting AC and DC currents, north and south poles, velocity and acceleration, alpha and beta particles, etc.

Step 4. Sequence & Consequence

The difference between these two forms of connecting sentences should be explained to the students. Consequences are a result of an action, while sequence is an event that follows the first but may not be caused by the first. The connectives to be used are:

consequence	sequence
causes...	to begin with...
leads to...	initially...
gives rise to...	after this...
brings about...	at the same time...
is caused by...	during...
is due to...	secondly...
is the result of...	eventually...
because...	subsequently

is the effect of... finally...

These two classes of connectives can be used with concept maps where the lower concepts are the consequence or a sequence of the higher ones. Examples can be given to the students such as:

Acceleration is a consequence of force. Subsequently a change in velocity or a change in direction may occur.

A battery causes a potential difference in a circuit because of stored energy. Eventually the battery energy runs out and no further current can be drawn.

Examples like this can be found from the topic you are doing and students can be set the task of writing such paragraphs. They can be used as relational statements on concept maps

Connectives are used in a wide range of writing but the connectives that can be used between phrases and clauses can be memorised by the pneumonic FANBOYS (Bailey ,1990). This stands for a number of connectives beginning with these letters eg:

F= for, furthermore, from,
A= and, almost, about,
N= not, nor, now, neither, nevertheless
B= but, because, before,
O= or, otherwise,
Y = yet,
S= still, sometimes, so,

Practice with these words by forming links on the concepts maps.

Step 5.
Students can practise joining up sentences from test papers and concept development sheets. An example is shown in Appendix B, using concept development sheets on electromagnetic induction and a second one on transformers

for students who wrote coherent paragraphs using a variety of connectives.

In the next section close attention can be paid to the way that paragraphs are written in the reading texts on the HyperCard Physics program.

The essay title for this topic can now be set. Students will need to start reading for their essay. The next lesson in the computer room will assist in this.

L-7&8. READING TEXTS and WRITING TASK PREPARATION

Preparation for the writing task can be done by beginning the 'essay concept map'. This is available on a second HCP stack which comes up automatically when ESSAY CONCEPT MAP button is selected on any card. To return to the first stack the students select GO BACK under the MAPPING menu which returns them to the card from which they left the first stack or by using the UP/DOWN arrow keys.

The essay concept map has all the concept mapping skills introduced in cards 1 to 19 plus the facility to extract concepts automatically from he reading texts of cards 21 to 30.

These students now know their essay title and are looking for concepts, connectives and writing styles. These tasks are carried out in the computer room and require a minimum of two lessons.

The reading texts are from a variety of popular science magazines and information booklets for example "Physics, Technology and Society" (Eastwell 1990). The ones provided in the HCP package have a suitable reading age level and are written in various styles. Pre-selected concepts have been "click chunked" and put in bold format. When a student clicks on one of these words or phrases, it is transferred to the essay concept map. The student should endeavour to find the meaning and sense of the word from the context in which it is used in the reading text. The lesson plan could go in the following steps:

Step 1

Turn on the computer. Select and open from student's own disc. Double click on the HCP topic. Double click on the stack icon "HCPcommence". Wait. Click on the 'reading text' button. This brings the students to card 20 This card explains the operation of the 'essay concept map'.

Step 2

At card 20 there is a new button called ESSAY CONCEPT MAP. When this is clicked another stack with a double size screen appears. To move around the double screen use the "scrolling hand" inside the little screen (rectangle in the bottom left hand corner). Try this. **Be careful not to get the border arrows which resize the screen.**

Step 3

Under MAPPING select 'LIST OF CONCEPTS and LIST OF RELATIONAL STATEMENTS again and to begin a specific essay concept map; NEW CONCEPT and 'NEW RELATIONSHIP can be used as well for the students' own essay concept maps. Return by selecting GO BACK under the menu MAPPING.

Step 4

From cards 21 to 29 there are a number of reading texts that can now be used for further knowledge about this topic. Read some of the cards that are relevant to the essay concept map and select words that are in **bold** by clicking on them. The concepts will be transferred to the essay concept map. Caution against selecting to many the words. When ready, click over to the essay concept map.

Step 6

The list of words that have been selected appear as a list down one side of the essay concept map These can be placed on the concept map according to the links with other concepts. Draw the link lines that connect these new concepts. Now select NEW RELATIONSHIP under MAPPING and put the new words on the links. This will help the writing task later. Go back to the reading texts for more words by clicking GO BACK under MAPPING or the UP/DOWN arrow keys. Not all concepts from the reading texts need be used.

Step 7

To make another essay concept map use the right arrow on the keyboard to come to a 'second essay concept map". This can now be used in the same way as before. When finished this, use the left arrow key to go back to the first essay concept map. In this way a number of essay concept maps about the topic can be made.

Step 8

When the lesson is finished select QUIT under FILE and then CLOSE the file and then eject the disc by dragging to TRASH. The program automatically SAVES.

Step 9

To print the essay concept map, go to menu FILE and select PAGE SET UP. Select landscape orientation. Now under FILE select PRINT CARD. The total concept map will be printed.

The teacher who is fairly familiar with HyperCard may wish to add to or delete cards from the stack of reading texts. See the Advanced HCP Program later in this manual.

L-9. LANGUAGE REGISTER OF SCIENCE

One classroom lesson is normally needed to prepare the students for the third section of the HyperCard Physics programs: the extended writing tasks. An initial requirements for the Writing Based Literacy Assessment and for the PES Essay is the conventional use of English.

Use the data show or transparencies for card 30 to 40.

CARD 30
This is a revision of the three decisions in beginning a writing task: genre selecting; language register selection; concept selection. This latter has been done with the completion of the essay concept map.

CARD 31
This card is a revision of the six genres of writing in science. The students will normally be writing *explanation* or *discursive argument* genre in this program.

A term being used currently by applied linguists and English teachers, is the word **genre.** It stands for the types of written and oral discourse, for example, letters, conversations, invitations, explanations, arguments etc. In science, a number of genres have been identified and students are encouraged to develop the full range in their writing tasks.

GENRE IN SCIENCE
A movement towards incorporating the teaching of a variety of genre in science has gathered momentum in recent years. Writers such as Martin (1991), Hardy and Klarwein (1990), Derewianka (1989), Painter (1988), Callaghan and Rothery (1988) and others have established practical protocols for the teaching of genre. The broad categories that are applicable to science teaching are:

- **Recount**, as in a narrative form about a certain discovery, or a new theory, or the life of a scientist. The form of language register will reflect this. The concept map can be in the form of a time line.
- **Report**, as for a laboratory exercise. This can incorporate many of the formal features of scientific writing.
- **Procedure** can be written for an investigation or a future laboratory exercise. The concept map can be in the form of a flow chart.
- **Explanation**, is a formal piece of writing, but it can be used with a variety of language styles. The concept map can be produced in a hierarchy structure or conceptual relationships as outlined earlier.
- **Exposition**. This normally takes an argumentative approach for one side. It reflects the opinion of the writer and for science must be based on empirical evidence. It may question some of the practices and conclusions that are currently used in science.
- **Discursive argument**. The writer attempts to give two sides of an unresolved problem and will use empirical evidence to support each side. The writer may pose a partial solution.

It is possible then to allow a range of genre to be used in science writing and to encourage students to use this range. In this program there is a focus on the *explanation* and *discursive argument* with an assessment scheme incorporated for the *explanation* type of essay.

CARD 32

This is necessary for the explanation of the language register of science. This can be given about one lesson according to the following steps. It may be worth asking advice from the English department, but students should see the science teacher being capable in using and teaching the elementary aspects of conventional English usage.

LANGUAGE REGISTER OF SCIENCE

Step 1

Introduce students to a summary of STYLE, TENSE, PERSON, MOOD and ask for further examples of each form. Advise the students of the necessity to be consistent in the use of the forms of language throughout any one extended writing task. Encourage them to talk about the styles used for various purposes. The conventional use of English covers:

- Style which can be divided into:
  - -technical, as in the case of specialised scientific journals.
  - -formal, as written in an impersonal account.
  - -informal, as in a personal response or report.
  - -slang, including colloquialisms. This has been found by Lemke to be advantageous to students in oral discourse, but given the intended audience of extended writing tasks, it should be discouraged in written expression.

  as well as including the "voice":
  - -active: Subject first: "The gamma rays penetrated the paper shield."
  - -passive: Object first: "The paper shield was penetrated by the gamma."

- tense of the verb
  - -simple and continuous present: "The electrons pass through the conductor." "The electrons are passing through the conductor"
  - -simple and perfect past: "The beaker of water was heated to 100°C"; "The beaker of water has been heated to 100°C"
  - -future: "Use of electronic devices will be even more widespread."
- person of the pronoun
  - -first: I, we, us
  - -second: you or you understood (not stated)
  - -third: they, them he/she

- "mood" of the verb:

-indicative: Saying what happened: "The current was switched on."
-imperative: Giving directions: "Switch the current on."
-subjunctive: speculating: "If you were careless, an electric shock might be felt."

- punctuation: the necessary full stops, commas, etc.

Step 2
Students can be asked to write a number of paragraphs using different conventional forms for example:
-Write directions for making an electrical circuit.
-Report your observations when the melting point of paraffin was reached.
-How is your concept mapping task developing.

Step 3
Reading these orally in class helps students in understanding the variety of conventional forms that can be used. Remind them that consistency is important in the writing tasks and that colloquialisms are not acceptable.

Step 4
Introduce the aspects of the scientific language register:

- SPECIALISED VOCABULARY

Scientific text allows the formation of abstract nouns from concrete technical nouns. Noun phrases and verb phrases are used to make new definitions. Definitions are expressed in words, symbols and equations. In the use of a specialised vocabulary, Halliday (1990) found seven major difficulties encountered by readers of science text. They were lexical density, technical taxonomies, interlocking definitions, spatial expressions, syntactic ambiguity, semantic discontinuity, grammatical metaphors. It is the task of the teacher not just to unravel the language of the above specialised difficulties, but to show the students how to unravel it. Some of these difficulties may be encountered in the **reading** texts of the HyperCard Physics programs and will need explanation by the teacher.

• PROPOSITIONAL STATEMENTS

These include statements of composition, processes, sequences, cause and effect, functional and mathematical expressions. Gardener (1977,1978) researched many aspects of student language difficulties in science that included logical connectives, illative connectives, non-technical vocabulary and other language difficulties. The use of a wide range of **relational statements in concept mapping** is designed to increase the students' ability in this aspect of the language register.

• EXPRESSIONS OF MEASUREMENT

Use is made in science of special units, instruments, quantitative and qualitative adjectives, proportional statements, and indicators of precision and accuracy. The ability to read and use the conventions of measurement and to have a 'feel' for the orders of magnitude is also part of scientific literacy. This is expected in **report writing** especially of laboratory exercises. Reports are an example of the genre that can be used in science writing and form part of the third section of the HyperCard Physics programs.

• LAWS AND THEORIES

Laws, hypotheses, rules and equations and are often couched in 'ideal' (meaning unreal) term for example "smooth', 'point source', 'test mass', and others. Knowledge of vector, mathematical and algebraic equations, and calculus expressions are part of the language register of science and can be used in expository writing and as **relational statements** in concept mapping.

• GRAPHS, TABLES, DIAGRAMS

These forms of communication are often used in scientific texts. The student needs to be able to extract meaning as well as use these forms of spatial representation of scientific text. Students are to be encouraged to use these expressions in their extended writing tasks. An example is the use of a linear graph to extrapolate Absolute Zero of the temperature of a gas. They are not specifically encountered in the HyperCard Physics programs.

• CALCULATIONS

The ability to perform calculations based on arithmetical, algebraic or calculus algorithms is necessary for scientific literacy as well as knowledge of applications of Laws and Principles. For example, molecular weight and mole calculations require arithmetic facility while differential calculus provides the relationship between acceleration, velocity, and displacement. These calculations form part of reports of laboratory exercises. They are not specifically encountered in the HyperCard Physics programs.

• CONTINUAL EVOLUTION OF LANGUAGE FORMS

New technological concepts, space technology and computer science are creating new forms of specialised vocabulary and new forms of expression. These expressions are becoming part of the science register of language, and are incorporated into the students' cognitive structure through transference of reading text concepts onto the essay concept maps.

L-10&11. EXTENDED WRITING TASKS

These two lessons are taken in the computer room and students will need assistance to transfer their essay concept map into essay form. As much verbal assistance may be given in this transfer without jeopardising WBLA because they are assisting with students' own work.

The students also find it easier to talk about the essay than to write it. Allowing students to discuss their essay will help them to more accurately articulate their **assimilation of scientific conceptual relationships into personal cognitive structures and communicate these conceptual relationships and critical analyses of scientific issues through the language register of science (The definition of scientific literacy).**

The flexibility of allowing students to use *discursive argument* genre will also help to establish their confidence and motivation to engage in public debate in later adult life and enhance the scientific literacy of the general public. This will help to overcome the problem perceived by Lemke (1982) expressed as:

> The inhuman character of science justifies the disinclination of the disenfranchised to claim a share of its power. The impersonal truth of science justifies its use as a metaphysical grounding for social acceptance that 'some things just are as they are', most especially 'human nature' and by implication the existing social order. And deep beneath all these, the acceptance that context-independent propositions may be categorised as 'true', laying the foundation for a mystification of the power of human authority to assert 'truth' and through it all other legitimation of power. The trail leads that far. If we do not question the possible disjunctive role, the ideological, system-stabilising functions of the very concept of 'truth', we have not begun to do critical analysis of science education, education or any other aspect of our own socio-semiotic system. Let anyone who thinks 'there is no point in dragging in all this ideological stuff in analysing science classroom discourse try to analyse the possible system-stabilising consequences of this very (disjunctive) belief. (p265).

It is clear form this passage that the teaching of genre in science is broader than the prescriptive statements that have been written for WBLA, and while attaining these objectives, it is possible to address the broader aspects of scientific literacy.

Some examples of different forms of questions in extended writing tasks are as follows:

Electricity

A. In what ways is electricity and its manufacture beneficial to humankind and what ways is it harmful. How can it be made more useful and less harmful to humans.

B. Write a letter to Michael Faraday (1831) to say how your life is affected by the uses of electricity. Show your knowledge of Physics by explaining to Michael the different forms of elect ricity and how they are generated. Describe how circuits and their various components are wired. Mention some safety devices.

C. Explain how AC and DC electricity are generated and how their various circuits make it possible for electricity to be used in many appliances. Explain some of the safety devices.

Magnetics

A. Explain from the point of view of a Physics student, how you encounter magnetism and electromagnetism in your everyday life.

B. Write a letter to Hans Christian Oersted to say how your life is affected by magnetism and electromagnetism. Show off as much Physics knowledge as you can

C. Explain the uses of magnetism and electromagnetism in our world today.

Radiation

A. You as a radio therapist have to tell your patient that he/she is to undergo radiotherapy. Explain as much as you can about the Physics of the procedure.

B. You have a close relative, who understands some Physics and has to undergo a diagnostic scan for a tumour. This will be followed by RA Cobalt or Iodine treatment. Explain as fully as possible to him/her about the procedure from your Physics knowledge

C. Explain the medical applications of radioactive isotopes.

Heat

A. Write the procedure you undertook in you experiments to investigate the Kinetic Theory of matter.

B. Explain how your experiments verify (prove) the Kinetic Theory of matter.

C. Write the procedure for treating an athlete, or baby who is suffering from hyperthermia.

The style of questions set for extended writing tasks will assist students to develop a range of genre in which to write.

L-12. ASSESSMENT OF STUDENT WRITING

A variety of assessment criteria have been developed for the WBLA to asses students writing as successful (S) or not successful in meeting requirements (RNM). This Scientific Literacy Development Plan is addresses the broader definition of scientific literacy and hence a broader assessment model is used.

The model chosen is that of Biggs and Collis (1982): the Structure of Observed Learning Outcomes (SOLO).This system or assessment is based on research into high school science from 1982 to 1989 and continuing. The SOLO taxonomy is based upon broad levels of understanding and reasoning that have been observed in a large variety of student writing. The levels have been termed: Prestructural; Unistructural; Multistructural; relational; and Extended Abstract. They are described as follows: (Biggs and Collis, 1989, P16)

> 1. Prestructural
> The task is not engaged or is engaged at a level below the mode of functioning required in the domain concerned.
>
> 2. Unistructural
> Joining in the "science game" with direct concrete reality the focus of attention.
>
> 3. Multistructural
> Series of discrete but less concrete aspects of observable reality are used as the basis for understanding scientific ideas.
>
> 4. Relational
> Representation of scientific concepts by generalised, but reality based, symbols become the key feature at this level.
>
> 5. Extended Abstract
> Ability to manipulate complex abstractions and formally test hypotheses becomes clear.

This scheme enables the assessor to grade the quality of science writing in the explanation genre according to both scientific and language features. The scheme was trialed until inter-marker reliability was established.

The *explanation* essay is assessed over five bands of criteria and an alphabetical grade is awarded for purposes of feed-back to students immediately after each application of SLDP. This can be regarded as formative assessment or used for summative assessment for WBLA

The criteria used for assigning writing pieces to a particular band are as follows:

- foundational criteria for a minimum standard that corresponded with the WBLA for the normal assessment
- multistructural criteria for the use of a range of scientific concepts and applications to every day life
- relational criteria within paragraphs for the logical connection and development of scientific expressions
- relational criteria throughout the essay for logical connection and development of scientific theories, principles and concepts
- extended abstract reasoning in which hypothesising, theorising and formation of 'open' conclusions where appropriate.

The practical application of this scheme is given in Appendix C.

HCP TROUBLE SHOOTING

The likely difficulties that students and teachers might encounter with the appropriate remedies are as follows:

TROUBLE	REMEDY
1. Not being able to type in the cards when required.	1. The student's disc is locked or the user level or HyperCard is not set at level 3.
2. In using mapping tools students forget to get out of 'drawing lines' and 'erasing'. 'Marching ants 'are seen.	2. If 'marching ants' are seen go to MAPPING and select FINISHED ERASING or FINISHED DRAWING LINES.
3. Getting a "Can't see that card properly" message when students click outside a concept.	3. Just click the "cancel". In future make sure to click with the finger of the browse tool right in the middle of the concept.
4. Resizing in the "essay concept map" can take place if the "scrolling hand" is not used in the middle of the scrolling window.	4. Resize back to about half a screen size with the resizing arrows at the borders of the scrolling window.
5. Getting a blank concept when a student selects "new concept" but then cancels. 'Marching ants' are seen.	5. Select finished 'erase concept' under MAPPING and erase the blank concept.
6. Students not putting their names on the concept map or essay.	6. Get them to write names into "new concept" and placing it in one of the corners for easy identification after printing.
7. Printing problems with concept map.	7. Make sure of 'landscape' orientation and then go to PRINT CARD under FILE.

8. Printing problems with the essay.	8. Make sure of 'portrait' orientation and then go under FILE to PRINT FIELD.
9 Any other problem	9. Go under FILE to QUIT and start again

ADVANCED HCP

Teachers can redesign the HCP program to suit their own needs

1. After opening HCP click on a card and blind type "reset menubar".

2. Set the user level to 5 in order to rescript the HCP.

3. Create any new fields or buttons as required.

4. To add definitions on card 13 script the following for the new button:

```
On mouse stillDown
show card field "definition of---"
End mouse stillDown
On mouseUp
hide card field "definition of---"
End mouseUp
```

Then for New Field Info
use the title "definition of ---"
Unlock the field and type in the definition.

5. To replace a reading text card 20 to 29:
   Unlock the field
   Delete the text of the field
   Type in the new reading text
   Select the concepts required in 'bold' and 'group' under 'style'
   Lock the field.

6. To add a new reading text card:
   Copy one of the existing reading text cards with 'copy card' in 'edit'
   then follow the procedure for 5 above.

7. To add model essays
   Copy one of the existing model essay cards with 'copy card' in 'edit'
   Unlock the field
   Delete the essay
   Type in the new essay.

8. To delete any card:
Choose 'delete card' under 'edit'.

9. To print the stack:
Choose 'print stack' under file
Resize according to requirements.
Print

10. Other procedures can be found in the various handbooks on HyperCard.

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Appendix 6.2a
Prototype of SEGAS

This was the first version used to see if an assessment scheme could be developed that would include scientific criteria as well as linguistic criteria.

Appendix 6.2b
Scientific Explanation Genre Assessment Scheme (SEGAS)

This was the final version of the Scientific Explanation Genre Assessment Scheme used for the first and second extended studies.

WRITING IN PHYSICS

CRITERIA (BEYOND WBLA)	none	little	some	much	GRADE
1. Legibility and set out? Required Length?	–	–	–		
2. Correct spelling and punctuation?	–	–	–	–	
3. Is the genre clearly evident?	–	–	–	–	
4. Is the language register consistent?	–	–	–	–	
5. Correct, adequate and variable sentence construction?	–	–	–	–	C-
6. Is the purpose of each paragraphs clear for eg definitional, comparative, consequential etc ?	–	–	–	–	C
7. The use of an adequate range of scientific concepts for this topic?	–	–	(1-5,6,7)		C C+
8. Is there an extensive use of connectives within each paragraph to fulfil its purpose?	–	–	–	–	B-
9. Within paragraphs, do the ideas engage or interest the reader?	–	–	–	–	B
10. Within paragraphs, is there a sequential development of scientific concepts?	–	–	(8,9,10)		B B+
11. Throughout the whole piece is there engagement of the reader towards forming a conclusion, solution or generalisation?	–	–	–		A-
12. Is the conclusion the inevitable result of all sections of the piece?	–	–	–	–	A
13. Is there technical scientific concept linking of theory, abstract, general and specific concepts?	–	–	(11,12,13)		A A+

SOLO taxonomy	General(G) or Scientific(S) Upper(U) or Lower(L)		Grade
EXTENDED ABSTRACT (different criteria for Year 12)			
RELATIONAL			
		12+13 RSU	A+
	RGU 12	13 RSL	A
	RGL 11		A-
MULTISTRUCTURAL			
		9+10 MSU	B+
	MGU 9	10 MSL	B
	MGL 8		B-
UNISTRUCTURAL			
		6+7 USU	C+
	UGU 6	7 USL	C
	UGL 1-5		C-
WBLA – S			
WBLA – RNM			

SCIENTIFIC EXPLANATION GENRE ASSESSMENT SCHEME

Criteria	Not Adequate (tick)	Adequate	Grade	Comments
1. Foundational criteria:				
• Legibility, layout and length	☐	☐	minimum standard to be met	
• Spelling, punctuation and grammar	☐	☐		
• Sentence and paragraph construction	☐	☐		
• Consistent language register	☐	☐		
• Fluent and coherent to the reader	☐	☐		
2. Multistructural criteria:				
• Foundational criteria met	☐	☐	C	
• Range of relevant scientific concepts and/or applications to everyday life	☐	☐	C+	
• NEGATIVE: Incorrect scientific concepts	☐		C-	
3. Relational criteria within paragraphs:				
• Logical development and use of language connectives between sentences	☐	☐	B	
• Specific scientific relations such as equations, word analogues or mathematical expressions that show the development and extension of concepts	☐	☐	B+	
• NEGATIVE: Incorrect scientific relations	☐		B-	
4. Relational criteria throughout the essay:				
• Logical development between paragraphs and progression towards a solution or conclusion	☐	☐	A	
• Linking of scientific theories, principles, and concepts with equations, laws and mathematical expressions that link all sections of the essay	☐	☐	A+	
• NEGATIVE: Misleading or scientifically incorrect application of the theory	☐		A-	
5. Extended Abstract Reasoning				
• Hypothesising, theorising and formation of open conclusion as in a discursive genre		☐	A+	

Appendix 6.3a

An example of a bibliographic recount

Appendix 6.3b

An example of a laboratory report

Appendix 6.3c

An example of a research report

Appendix 6.3d

An example of a scientific explanation genre essay

Appendix 6.3e

An example of a discursive argument essay

Appendix 6.3f

An example of a letter response

Appendix 6.3g

An example of a poem

Isaac Newton was the (culminating) figure of the scientific revolution of the seventeenth century. He was an English physicist and mathematician, in optics he laid the foundations of modern physical optics, in mathematics he was the original (discoverer) of the infinitesimal calculus, and his three laws of motion are the basis of mechanics.

developed ?? Discovered

Isaac Newton was born on the 25th of December, 1642, in the hamlet of Woolsthorpe, Lincolnshire, England. He was the son of Isaac Newton and Hannah Ayscough, though his dad died before his birth. His mother remarried two years later, leaving Isaac with his grandmother. Isaac's childhood was a sad one, he hated his step-father and he remembered, 'Threatening my father and mother Smith to burn them and the house over them.'

Newton's schooling started at Grantham Grammar school, and after a stint at farming, Newton returned to Grantham to prepare for university. Newton left behind in Grantham many accounts about his mechanical ability, and his skill in building models of windmills, clocks, and machines. At Grantham he learnt to master Latin but only basic arithmetic. After a very interrupted education Newton matriculated at Trinity College, Cambridge by June 1661.

Newton arrived at Cambridge in 1661 and the scientific revolution was well advanced. Galileo who died the same year Newton was born, had proposed the foundations of mechanics based on the principle of inertia. Philosophers and astronomers were also both in

SIR ISAAC NEWTON

Newton in oil painting by Sir Godfrey Kneller, 1702

full swing.

Newton began his higher education by immersing himself in Aristotle's work. Newton also discovered?? the work of René Descartes, a philosopher, who's work was in contrast to Newton's. Newton's work in chemistry was based on the work of seventeen century chemist Robert Boyle.

?? Grammar.

In 1664 Newton finished writing a set of notes named, "Certain Philosophical Questions", and under the title was written the slogan, 'Plato is my friend, Aristotle is my friend, but my best friend is truth.'

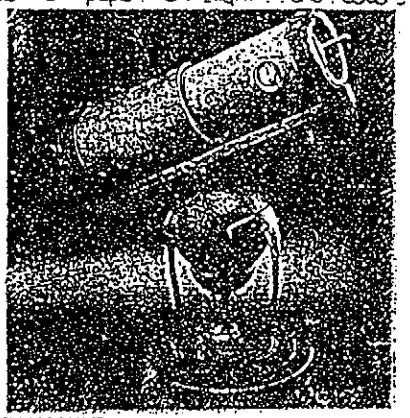
In April 1665 Newton recieved his bachelor degree. Newton's work in mathematics also began, he discovered the binomial theorem and he developed the powerful form of analysis named calculus. By 1669 Newton wrote a ? (tract) known as, 'On Analysis by Infinite Series', and during the next two years his revised version came out known as, 'On the Methods of Series and Fluxions.' Newton had now arrived at the point where he was the leading mathematician in Europe at that time.

In 1665 and 1666 Newton performed a series of experiments in which the spectrum of a narrow beam was projected onto a wall of a darkened chamb.

SIR ISAAC NEWTON

After these experiments Newton held that individual ray excite sensations of individual colours when they strike the retina of the eye. He also concluded that rays refract at distinct angles, and that phenomena such as the rainbow are produced by refractive analysis. Newtc then turned to reflecting telescopes and constructed the first ever built.

In 1667 Newton was elected to a Fellowship in Trinity College. Two years later, in 1669 Isaac Barrow resigned the chair to devote himself to divinity and recommended Newton as his successor. Newton's first choice as professor was a course in optics, which continued from 1670-72. His lectures developed the essay, 'Of Colours' into a form which was later to become Book one of his Opticks. In 1671 the Royal Society heard of Newton's reflecting telescope and asked to see it, after being elected into the society, Newton volunteered a paper on light and colours early in 1672.



Sir Isaac Newtons reflecting telescope.

In 1675 Newton sent a new paper entitled "An Hypothesis Explaining the Properties of Light". Hooke claimed this was plagiarism of his work and this dispute was never settled. The same year Newton wrote another book name 'Hypothesis of Light'. Around 1679 Newton abandoned the ether idea, which was in 1675 and now began to ascrible to such phenomena such as surface tensions in fluids, and chemical reactions. Thirty five years later, in his second edition of Optick he reverted back to his ether idea.

Newton dealt with orbital dynamics in 1679 and 1680 yet he had not yet arrived at the concept of universal gravitation. Nearly five years later in 1684 Newton wrote a tract entitled 'On Motion'. Newton also wrote 'Planetary motion', an exact quantative description of the motion of visible bodies, based on Newton's three laws of motion. His first law, of course, states that a body remains in its state of rest until acted on by an unbalanced force. The second law states that the change of motion is proportional to the force impressed, and the third states that for every action there is an equal and opposite reaction.

In London, Newton assumed the role as the father of science. He was elected president of the Royal Society in 1703. In 1705 Queen Anne knighted him, the first scientis with this honour. After a long and fruitful life Sir Isaac Newton died in 1727.

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SACE 1

PHYSICS EXPERIMENT

PRAC REPORT

AIM

To determine and state the relationships between Force / accel and mass / acceleration.

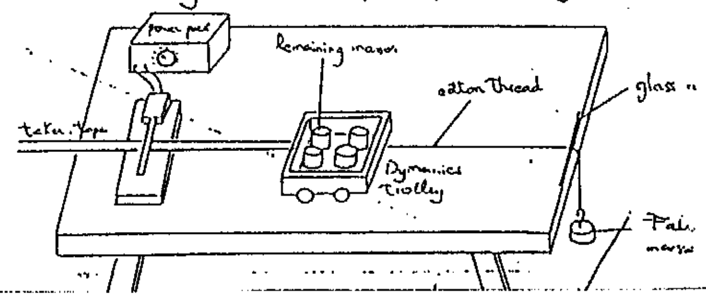
EQUIPMENT

- Dynamics trolley
- Ticker timer
- glass rod
- Ticker tapes
- Wooden blocks (100g)
- Masses
- Cotton thread.

METHOD

Part 1 (Mass constant)

1. Connect the ticker timer to the power supply
2. Attack a length of ticker tape to one end of the troli and pass the tape through the timer.
3. To other end of the trolley attach a length of cotton, att. the other end to one of the masses
4. The remaining mass must be placed in the trolley.

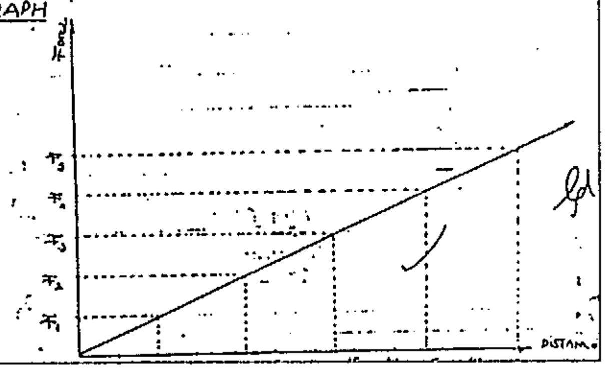


5. Start the timer, release the trolley and mass at the end of the cotton thread because of the gravitation the mass would fall down until it reached the floor, that move all system except the ticker timer. Label this tape 'Force 1'
6. Transfer one mass from the trolley to the end of the cotton. Repeat step 5 and label this 'Force 2'.
7. In the same way get tapes for 'Force 3' 'Force 4' and 'Force 5'
8. Acceleration is proportional to distance S: ½at². starting with 'Force 5' tape count the number of tick intervals from the first clear dot to near the end of tape. Measure the distance travelled.
9. Repeat step 8 for the other tapes and fill in the table

RESULTS

Force	Distance Travelled (cm) in first 10 tick intervals
F1	10 cm
F2	23 cm
F3	33.8 cm
F4	44.5 cm
F5	50.5 cm

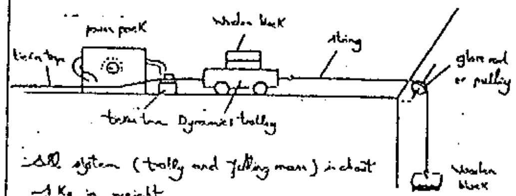
GRAPH



* This graph could be as that relationship between the quantities of force and quantities of acceleration is a straight line when they start at the origin. The force increases in the acceleration increases too so we can say that for constant mass the acceleration is proportional to the force. This proportionality relation also implies the direction of force is the same as the direction of acceleration. $a \propto F$.

Part 2 (Force constant)

1. Repeat step 1.2.3 from part 1.
2. Without wooden blocks on the trolley, start the timer, release the trolley and obtain a tape of the motion. Again reject any part of the tape that is made after the block hits the ground label this tape 'Mass 2'.

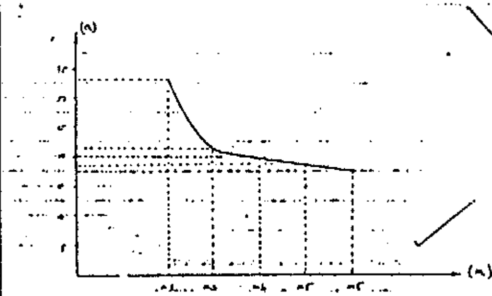


All system (trolly and falling mass) is about 1 kg in weight

3. Place one wooden block in the trolly and obtain a tape of the motion as above label this tape 'Mass 3'.
4. In the similar way, obtain tapes for 'Mass 4' 'Mass 5' and 'Mass 6'.
5. Repeat steps 8 and 9 from part one.

RESULT

MASS	DISTANCE TRAVELLED(cm) 10 ticks
2	30.31
3	21.7
4	20.1
5	19.6
6	18.9



* Look at the graph we see the relationship between the quantities of acceleration and quantities of mass is a curve when the mass increases it decreases.

For a constant force F, the magnitude of the acceleration is inversely proportional to the mass of the accelerated objects

$$a \propto \frac{1}{m} \text{ (constant } F\text{)}$$

CONCLUSION

1. In part one it was necessary to transfer the masses from the trolley to the end of the cotton rather just adding more masses to the end of cotton because when we transferring the masses from the trolley to the end of cotton it meant the mass of system was constant and at the same time force can be change. There were 5 Forces. The small one was proportional to the acceleration of the small magnitude and the large magnitude of force was proportional to the large magnitude of acceleration. So for the constant mass the acceleration was proportional to the force ($a \propto F$).

2. In part two the mass of the falling be added to the mass of the trolley and t[he] mass of block was only put on the trolley so t[he] constant. There were 5 masses, the one with magnitude was the big magnitude of acceleration contrary way the one with the big magnitude magnitude of acceleration. That mean more (with greater inertia) accelerated more slo[w] massive object when the same force.

Generally,

Two proportionality relations can be combin[ed] equation

$$F = m.a$$

For constant force F, the magnitude of the [acceleration] was inversely proportional to the mass of the o[bject]

$$a \propto \frac{1}{m} \quad \text{or} \quad am \propto \text{a constant}$$

* I have learnt when going through this prac[tical]:
- For constant mass, the acceleration is pr[oportional] to the force $a \propto F$.
- For constant force, the acceleration is [inversely] proportional to the mass of the accelerated object $a \propto \frac{1}{m}$

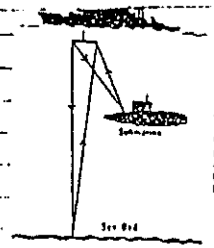
ULTRASONICS PROJECT:

A Sonar is a device used for detecting the presence of submarines. It may be fitted to other submarines, surface ships, or dangled in the water from a helicopter. Sonar is also used for communicating with submerged submarines. The name sonar stands for SOund Navigation And Ranging. In Britain before the end of World War II it was known as Asdic.

A version of sonar called an echo sounder is used for measuring the depth of the sea and for finding fish. In echo-sounding, a transmitter sends sound waves down to the sea-bed. The sonar then measures the time taken for an echo to bounce back to the ship. (Echo is the sound that bounces off a distant object such as a cliff, in much the same way as a ball bounces off a wall or light is reflected off a mirror. If you make a noise near a suitable reflecting object such as a tall building you hear the echo a little time later. Sound travels at 1,100 feet per second. It takes a second to go to an object 550 feet away and return.

Bats avoid trees and buildings by bouncing their supersonic squeaks off them. Seamen use sonar to measure the depth of the sea by recording echoes through the water.)

Because the sonar operator knows the speed of sound through water (about 4,900 feet a second) he can use the time measurement to work out the depth of the sea. The rao



Location device used to detect submarines. Ultrasonic signals emitted under a ship bounce off the submarine and the echo is detected by the ship, indicating the submarine's position. The depth of the sea bed can be found in the same way.

Sonar is just one of the many uses that engineers and scientists have found for ultrasonic sound, which is often called ultrasound. These are names for sound that is too high in frequency to be heard. The average person can hear sound waves that range in frequency from about 20 to 18,000 vibrations per second. A dog can hear vibrations as high as 40,000 and the hearing range of other animals goes even higher. The waves used in sonar have a frequency of 25,000

For most of the practical uses of ultrasound, the waves have frequencies from about 20,000 to 1,000,000, although frequencies as high as 10,000,000,000 (ten thousand million) have been produced in laboratories. Ordinary sound waves are usually a few feet long, but ultrasonic waves are measured in hundredths of an inch or less. The very short wave lengths of ultrasound make a great difference in what

changed into a little cloud of mist. Shoals and small fish could be killed by putting the vibrating crystal into an aquarium. These experiments were exciting stunts done thirty years ... really nothing compared to the innovations of today.

Ultrasound literally means 'above sound', which it is, about 18,000 vibrations per second and above.) Rev

I think in the future ultrasonics will be the key to communication between long distances, maybe we could design it so that we could communicate messages straight to the brain from a computer and vice versa, all the big equipment would not be needed. The only problem is the speed, which is only 3×10^8 m/s, which is too slow if spaceships were travelling large distances. It will definitely become a vital part of our lives in the future for cleaning, dentistry, medicine and host of other activities. The only problem is that I can see it at a large scale as a harmful weapon.

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An illustrated coursebook Physics
All about Sound and Ultrasonics.
Junior world encyclopedia

[illegible]

Electricity, nowaday, is used widely by everyone in society in the form of light, heat, and energy. It is even beneficial to handicapped people. Electricians have improved special equipments such as spec appliances in household, electrical wheelchair, and the (EMG(electromyogram) on the purpose of serving these people.

Appliances such as switches, power boxes are specially designed in the households of handicapped people by electricians in a way such that they are convenient for them to use. They must be at an averag reach because handicapped people cannot reach too high or too low. It is difficult for handicapped people to walk up the staircase, conv belt is designed to bring them upstairs.

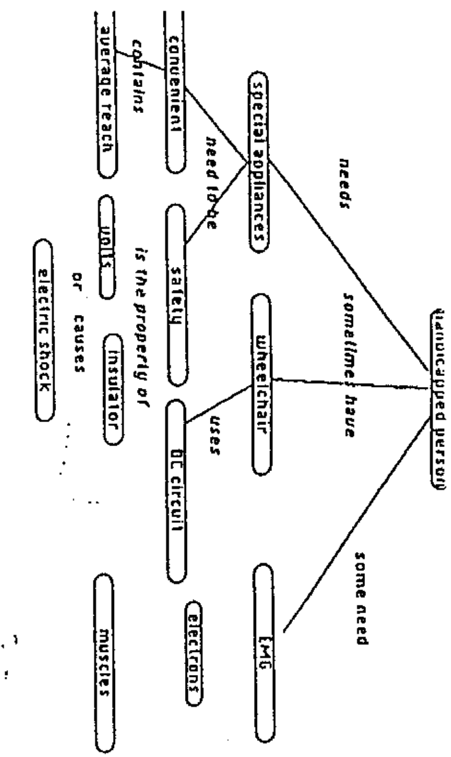
The safety in these electrical appliances is highly considered by electricians. They must have good insulators and are checked once i a while. Otherwise, an electric shock may happen and cause fatal danger to people.

Some handicapped people need wheelchair to help them to move arour It is hard for them to move the wheels by their hands. Electricians fix this problem by placing a battery, an electric motor and a variable resistor onto the chair. The potential difference of the wheelchair's battery is only half of that of the car battery, which i about 6V, and the current in the battery is dc. The battery creates a electric current which makes the motor work and move the wheels. The variable resistor acts as a circuit breaker which turns on and the battery. The battery can be recharged so it is convenient and economically for the users.

Electromyogram (EMG) is the visual recording of electrical activity of the muscle. Normal muscle is electrically silent when it is at re but an electric current is generated when it is active. The action potentials (impulses) are shown in the screen as wavelike tracing.

Some handicapped people need electrical treatment for their muscles The weakness of the muscle is caused by the impairment of the nerv supplying it or by the muscle impairment. A low current stimulate the sensory nerve ending and the muscle tissue when the current is closed or open. It acts as a "shock". Surges of alternating current i used to cause contraction of weak paralysed muscle and step up the poor circulation in the limps of the patients.

In conclusion, electricians have raised the quality of life of handicapped people a lot through the designing of special appliance: electrical wheelchair, and the EMG. This is not the end. In the future, handicapped people may be benefitial more from the electricians.



A Discursive Argument about the effects of electromagnetic fields from nearby power lines.

In a report that I read in New Scientist 24 March 1988, I found there was divided opinion about the effects that electromagnetic fields under power lines had on human beings. Some people say these fields cause cancer while others dispute this.

Addey, Byus and Peiper of the University of California at Riverside have published research showing that electromagnetis fields affect the development of mamalian cells, including human cells, grown in culture. The claim that the fields of the strength associated with overhead power lines can promote the growth of cancerous cells. (New Scientist 3 December 1987, p 28).

However the chief medical officer of Britain's Central Electricity Generating Board (CEGB) said that Addey's work could bot be replicated and that the study was unique. The CEGB had set aside nearly $1m to study possible links between fieds crested by power lines and possible links with cancer especiallly leukemia in children. However they would not be conducting research into cells grown in culture.

Addey responded that the claims that the California study could not be replicated was "fraudulent" and was able to quote a study by the Naval Medical Research Institute in Maryland (USA) that found that electromagnetic fields can cause malignancies in chick embryos.This controversy has caused the CEGB to appoint a University professor, Sir Richard Doll, to oversee the British study into possible links between electromagnetic fields and childhood cancers.

I fell happier about the fact that the CEGB has appointed someone outside their own organisation to watch over the study, which is of such vital importance for many people around the world who live near overhead power lines. (Written in the HyperCard program)

Construction Manager
45 Pinre St.
Port Pk S.A. 5998

25th March 1999.

To whom it may concern.

I am writing in regard to an article in the Advertiser, 19th March 1999 about the construction of the Hewen Bridge. In this article it provided a plan of the bridge and the materials which will be used.

I am a Civil Engineer and I work for Edward's and John's Consulting Firm. I graduated from the University of Adelaide and received my degee of Bachelor of Engineering (Civil) at the Honours grade. As a Civil Engineer I plan, organise and supervise the construction and operation of projects such as bridges, dams, roads and large buildings. I work with a large team of professionals and skilled people. I also co-ordinate and direct research on the development and improvement of different materials as well as analyse reports on the quality and performance of these materials. I may advise contracters on materials most suited to individual construction needs.

From my ongoing research I can soundly conclude that the materials for the construction of the Hewen Bridge are unsuitable. The City of Uews is widely known for its disasterous weather patterns. In previous years the city has experienced great winds, hurricanes and many other natural disasters. The Hewen Bridge may collapse due to one of the above weather conditions. A similar incident which happened in 1940 may occur.

> *"In 1940, four months after being completed, the Tacoma Narrow's Bridge in the state of Washington was destroyed by a forty mile per hour wind. The mild gale produced a flutuating force that is said to have resonated with the natural frequency of the bridge, steadily increasing the amplitude over several hours."*
> CONCEPTUAL PHYSICS by PAUL. G. HEWITT

If successful impulses are applied on an object and matches its natural frequency then a dramatic increse in amplitude may occur. This phenomenon is called resonance. The term amplitude means the maximum displacement of a wave. When minimum energy is required to make an object vibrate then the object is vibrating at its natural frequency

Fatigue is the reduction in strength of which metals fail when they are subjected to fluctuating loads. Resonance may cause fatigue because there is a continual force on the object making it oscillate a greater distance. A lot of energy is exerted on the object which sets it into vibrations so violently that it may shatter. Large bodies of troops marching over brides are sometimes required to "break step" because the rhythmic pounding of the boots may set up resonance in the bridge which could lead to structual damage. It is possible that the frequency of their marching may coincide with the natural frequency of the bridge and set it vibrating in sympathy untill it fractures.

Therefore destructive vibrations may be built up because of resonance

I urge you to spend more money on the research of the materials nee

to construct the Hewen Bridge as there is a great risk of it collapsing in certain weather conditions. Don't let this be a repeat of the incident which occurred in 1940.

Yours Sincerely.

AUNTY JANE

AND THE INCLINED PLANE (RAMP)

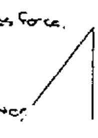
hat Aunty Jane,
...er of the Inclined Plane,
the age of 96,
...s spent her time hauling bricks.
...w, Aunty was getting old,
...t quite as brave nor so bold.
... her wisdom she said to me,
...on, Gravity's not what it used to be.
...aul bricks everyday,
...ere's got to be a better way.
...also work at night,
...t this stupid construction site."
...e truth is Aunty's not so slow,
...e knew exactly where to go.
...the Library she did speed,
...d immediately began to read.
...e learned of forces and vector laws,
...l to help her saintly cause.
...hat was her cause?" you say.
...lift bricks a better way!
...u see, nothing made Aunty madder

1 There is its label,
And with it we are able,
To calculate component forces with ease,
Hand me the calculator if you please."
I gave it to her as fast as a lightning bolt,
But she already had the result.
"To find the perpendicular force without being fussed,
Using Cosine is a must.
The gravity vector is the hypotenuse,
So let's calculate - we've nothing to lose!"
I got the impression,
That Aunty was far from depression.
She wrote figures as fast as she could career,
Here's what she wrote down on the paper:

Hypotenuse : Weight
H : W
H : 562N

Adjacent : Perpendicular force
A : ?

"What was her cause?" you say.
To lift bricks a better way!
You see, nothing made Aunty madder
Than hauling bricks up a ladder.
It hurt her feet and her back and gave her blisters anyway.
She didn't get compensation pay.
She studied hard and she studied late,
And soon discovered that the force of gravity on an object
is that object's weight.
"Weight," she said with a dose of mirth,
"Is perpendicular to the earth.
"That's downwards," she said matter-of-factly,
But I didn't understand exactly.
She said "It's represented by a vector, directed down."
She said it with the meanest frown.
I guess she thought I was a dummy,
Which made me feel pretty crummy.
But she soon continued with a smile,
Which made me feel better by a mile.
Then she came across the Inclined Plane,
Which seemed the answer to her pain.
Soon she got reward for her persistence,
When she found it could be used to lift weights over a distance.
I was quite impressed,
I couldn't wait to hear the rest.
In fact I was downright keen,
To hear about this brilliant machine.
"The inclined plane is a simple machine in disguise."
Said Aunty, who I thought was pretty wise.
"A simple machine allows you to do the same work a different way."
To me that sounded quite OK.
After that though I began to really worry
Aunty's descriptions were getting complicated in a hurry
She said bricks could be moved over a distance,
To lessen gravity's resistance.
You see, moving up a ramp takes less force,
Than going straight up, of course.
I was a bit confused,
But Aunty just seemed amused.
She went and drew it on paper,
So my thoughts would be straighter.



Adjacent : Perpendicular force
A : ?

Cosine θ : Adjacent / Hypotenuse

Cos θ : A / H

Cos 50° : A / 562

Cos 50° × 562 : A

A : 361N (adp)

Perpendicular Force : 361N perpendicular to the slope.

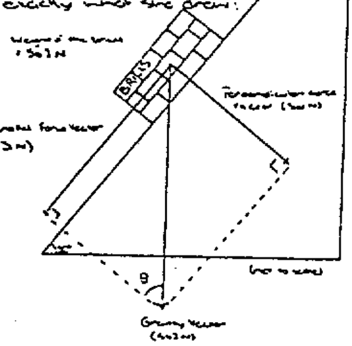
2 "There," she said with a smile.
She was ahead of me by a mile.
The parallel force is the rest,
For that Sine is best
Once again her mind did race,
as she wrote figures all over the place.
Just in case you want to see,
Here's what she wrote for me:

Hypotenuse : Weight
H : W
H : 562N

Opposite : Parallel Force
O : ?

Sine θ : Opposite / Hypotenuse

She went and drew it on paper,
So my thoughts would be straighter.
Her drawing gave me a clue or two,
Here's exactly what she drew:



It's all very easy," she said with a wink,
All you have to do is think!
If I tried to lift the bricks I could not cope.
But I could quite easily move them up the slope.
If you bear with me a few moments,
You'll find that the weight force becomes two components.
One called the Perpendicular Force,
Is 90° to the slope of course.
The parallel force (parallel to the slope) is the other one,
It's ages since I've had such fun!"
Actually I was not impressed.
But to concentrate I did my best.
Between the two are 90 lots of one degree,
Which we'll use with trigonometry."
"Oh no!" I cried in pain,
Alas it was in total vain.

$\sin\theta = \frac{\text{opposite}}{\text{hypotenuse}}$

$\sin\theta = \frac{O}{H}$

$\sin 50^\circ = \frac{O}{562}$

$\sin 50^\circ \times 562 = O$

$O = 431\text{N (0dp)}$

Parallel Force = 431 N along the slope.

"Good gracious me! I've done it!", she cried.
The Librarian nearly died.
To shout, scream, cry, whistle or call,
Is not allowed in Libraries at all.
"I wonder what happens if you change the size of the angle," she
While doing some more calculations in her head
"As the angle increases,
Surely the perpendicular force decreases
The parallel force must get bigger."
She said with lack of vigour.
"That means the greater the slope the more work to do,
But why shouldn't the person who works be you?"
To get that idea out of her head,
"I don't believe you," I bluntly said.
"Try it and you'll see,
Use some more trigonometry."
Her reply came loud and strong
How could I ever think her wrong?
I didn't do the maths there and then,
But later found she was correct again
"What remains is for us to make a prediction,
About the force of friction."
She promptly stated,
Sounding quite elated.
"Just a little extra might
Will move the force out of sight.
Rolling friction is less.

Which we'll use with trigonometry"
"Oh no!" I cried in pain,
Alas it was in total vain.
"Don't panic, we're in no hurry."
She said to ease my fearful worry
"The advantage is of course
All I'll have to move is the parallel force.
I admit I'll have to move it a greater distance.
But there's nothing you can't do with persistence
This is what eventually we do you see,
It's all to do with energy.
You can't make it come or go away,
You simply use it a more convenient way.
"Mechanical Advantage" is its name,
Still it's a shame,
As you'll see
That energy is never free.
For better or for worse,
That's how God made the Universe."
I was beginning to get the idea,
My thoughts were becoming clear.
To calculate the component forces she did hasten,
As if it would save the nation.
The way she thought best for me,
Involved trigonometry.
That word made my nerves tangle.
Meanwhile on the diagram Aunty sketched the dotted rectangle.
"50° is the slope's angle,
So is the angle of the bottom left triangle.

Will move the force out of sight.
Rolling friction is less.
Than sliding friction I guess.
That's no big deal,
We'll simply make use of the wheel."
What she was up to I wasn't sure,
But she seemed about to tell me more.
Aunty said, "Now that I've finished my tricks,
Let's relate this back to bricks.
Ladders are rotten for freight,
But for bricks ramps are simply great!
I'll wheel the bricks up as you'll see,
It'll be easy as 1, 2, 3.
Of frictional forces there will be a lack,
Thereby helping save my back.
The parallel force will be smaller than the weight.
The energy I save will be extremely great!
I was happy too,
Because suddenly I knew,
Exactly what she meant,
I understood one hundred percent.
The Librarian said we had to leave.
And Aunty said she hoped I'd achieve,
Far more than she had done,
Because I was the younger one.
I thanked her kindly and she went away.
We haven't met again to this day.
But from what I hear,
Aunty's now a structural Engineer,
All because Aunty has the brains,
To make good use of inclined planes,
And that's where she met Uncle Xavier,
Whose personal hobby was the lever...

Bibliography.

Secondary Physics Course (1975)	E.G. Jones	Pergamon Press
An Illustrated Coursebook Physics (1982)	Martin Hollins	Macdonald Educational
Physics 11 (1985)	A.L. Davies	Longman Scott
Learning Physics (1982)	Stephen Pople	Oxford University Press
Physics Principles & Problems (1977)	Zitzewitz	Merrill Publishers

Other assorted resources eg encyclopaedias, magazine articles etc

Appendix 6.4
First extended study post-SLDP student survey form

This questionnaire was administered to assess students' opinion about the value of the components of SLDP after they had used it.

SLDP STUDENT SURVEY

1. Did you enjoy the special lessons of SLDP?---Yes-------------

Why?-Something different (using computers)

2. Do you think that writing about this Physics topic helped you to understand it better? (TICK)

no help---a little help✓--some help---much help---great help---

3. How much have the following techniques helped you in your writing?
(a) concept maps (TICK)
no help---a little help---some help✓--much help---great help---

(b) using the computer (TICK)
no help---a little help---some help---much help✓--great help---

(c) the reading texts (TICK)
no help---a little help---some help---much help✓--great help---

(d) lessons on sentences and paragraphs (TICK)
no help---a little help✓--some help---much help---great help---

(e) the model essays (TICK)
no help---a little help---some help✓--much help---great help---

4. Do you think you will use any of these techniques again? Which ones?

--maybe - concept maps ~~std~~------------------

----

5. Number a 1st, 2nd, 3rd for the ease of writing in these subjects, if you do them:

Hist/ Geog/ Econs--2nd----

Eng --1st----

Physics --3rd----

6. Which "genre" (Recount, Report, Procedure, Explanation, Exposition, Discussion) do you like to use in writing in these subjects:

(a) Hist/Geog/Econs----Report-----------

(b) Physics----Explanation---------

(c) English----Exposition/Discussion

7. Do you think you will do Physics next year in Year 12?---Yes-

Why?--to have a wider choice-----------------

8. Where do you read about Physics ideas from?

(a) books from the school library? (TICK)
never--- a little--- sometimes-✓ much--- very often---

(b) books from a public library? (TICK)
never--- a little--- sometimes--- much-✓ very often---

(c) science magazines? (TICK)
never--- a little-✓ sometimes--- much--- very often---

(d) science in newspapers? (TICK)
never--- a little-✓ sometimes--- much--- very often---

9. Do you watch science shoes on TV?

(a) "Beyond 2000" (TICK)
never--- a little--- sometimes-✓ much--- very often---

(b) "Quantum" (TICK)
never--- a little--- sometimes-✓ much--- very often---

10. Do you think you are a good writer of science?---No------

Why----Not very clear with ideas expression and concept.

Thank you.

Appendix 6.5a

Transcript of interview with student

This is a transcript of one student's interview with the researcher given some weeks the completion of the SLDP.

Appendix 6.5b

The corresponding essay

This is the essay written during the course of SLDP.

Appendix 6.5c

The corresponding concept map

The concept map was drawn during the use of the HCP module on the "Dynamics" topic.

A STUDENT INTERVIEW

(I: the researcher, S: the student)

I. You know when you did your writing, I think you were saying to me that you were so expressive that you found it a little bit hard to get the physics into it---

S. Yea, I did and then---at that stage I didn't have any physics content but I---because of the use of the computer I could work out--structure.

I. Yes

S. and that's what I liked---I liked the concept mapping idea. I had come across that mapping idea before.

I. Have you?

S.---ahm---kinesiology---mmmmm---all of them ideas when they have a concept map you put down--- the main essay topic and then from there you just put down random thoughts---and then you make a shape out of it.

I. So you found it a good technique.

S. I liked the technique--I think that if you were taught that technique from young it would be great.

I. Yes, yes.

S. Yea, because I mean when once you have learned it, it's very---ahm--

I. It's quick?

S. It's quick, it's, it's so obvious.

I. Yes

S. It's great

I. What did you find different in this one say from the one in kinesiology?

S. I found it the same except this is the best one I have done---because on the computer and also you had given me pre----pre-programmed ideas.

I. pre-readings?

S. Pre-readings. You gave me them which stimulated my thoughts, which is the main reason why I liked. it

I. What did you think of the readings J?

S. Which were the little ones (on the computer)?---I liked them. I thought the information was really interesting---ahm---and I actually read all of them.

I. And you chose human movement (to write about)?

S. Yep, I wanted that, any way because that is what I like, but I enjoyed reading the ones about car safety and others. I found it was in good , a good language

I. Yes

J and it kept my attention.

I. That's good, and why did you pick the topic?

S. Human movement?

I. mmm

S. That's just my---that's something that I want to specialise in.

I. Is that I right

S. Yep. The uni course I want to do is called Human Movement, ---so that's why.

I. Oh yes and did you feel the physics content here helped you in understanding the ideas of human movement better?

S. Ahm---I find problems with formula anyway. I mean I know human movement anyway on a anatomical ---psychological level but I don't know it on a physics level, formulas equations level.

I. So what did you find hard in the actual writing?

S. ---ahm---well for me to make---to link up---my ideas with some practical, ahm, facts. I mean I---I either have the practical facts or I have ideas and I find it too hard to link---

I. to put them together?

S. Yes to put together.

I. Did you feel the concept mapping helped you put them together?

S. Yes, definitely. Well it kept me thinking about them and using the correct word, I think the problem is knowing that---impact is an acceptable word, mass and velocity, things like that. I'd put weight for mass normally, velocity I'd put speed, and to get me out of those habits you have got to have something continually there ---like, you know, having something like the words already there---

I. The prompt words?

S. The prompt words, that's right the prompts words.

I. And did you use the ones under "new concept" yourself or did you use the list concepts? Can you remember?

S. I'd say I used half and half. I put in a lot of---I used a lot of my own small words instead of the--- I didn't use the list---you know how you had "the" "as" instead--- I just found it more easier to press "new concept' and type it in---then, then---

I. Going about looking for the list

S. Yea, I hate running the line down and pressing the word---because it slips and---

I. You can't get the exact one you want.

I. Yea, and get another one and also the writing that it produced is different---the one that is---

I. Italic?

S. Yea, italic, and that put me off too.

I. Did it?

S. Yea. I would have preferred it to be just straight, plain. print

I. Ah good then, thanks for that. And you know in this topic "human movement" have you experienced this at all? Because you wrote about ballet and you wrote about---

S. Oh yea,

I. So that 's what I was wondering, how did your experiences get related in you essay?

S. Oh right,---well I suppose---you know things from experience what I wrote about the ice skaters and about standing still and someone coming up—you know things like that, everybody that tries ice skating knows that--ha--ha--because you will be out there standing on the ice and someone will come along and bang straight right into you, and you can't—and then of course you move. So you know these things but I have never questioned why this happens. I just go along with it. And then also,— as a technique you use it to create ice dancing or partner dancing, so---it's a great thing, but I have never thought why. And then when I do find out why, I get really excited about it.

I. So you can write easier about it when you are excited about it.

S. Oh definitely, I think "wow", I never really thought of that.

I. In other essays with physics have you found it the same or was this one better, you know easier to write about?

S. This one was much easier. I got 15 for that!---amazing---even for what I did--because when I came to do it I got confused half way through---the first time I lent too much away from the physics formulas and the next time I was leaning too much into the physics formulas so I still hadn't married the two properly so ---I just did my best and I got 15!

I. Yes

S. Which if I had done it cold---without the computer---I am sure I would have got less. I am finding now that computer work, writing things on computer is ---twice as good---you can see what you are doing--

I. And read it?

S. You can read it. You can rearrange it, I even see where my spelling mistakes are and where commas need to go and it is really good to change the words around.

I. In this program there are a number of reading ideas too. Now if you were doing another physics topic, altogether how do you feel about the reading ideas.

S. The ones that you put on the little---

I. The cards

S. The little cards. Oh, I would look at them too. I always need something written by someone else to stimulate me to write---something.---and I am quite good at writing chemistry essays---things that have facts in them--so that there is something you can rely on--and you can build around it.

I. You can get your own ideas going once you have got a few starting ideas.

S. Definitely. you think "Oh I see, it's not that hard, and you know what it is they're asking"

I. Yes and concept mapping helps you plan that in a structured way?

S. Yea. I like concept mapping. I think it's a good idea.

I. Now you have said a lot about the computer process so you liked that?

S. Oh I loved it. It's great

I. Yes. Some people don't like using computers and other find it's quicker etc

S. Well I have never used a computer until I came here. I don't even have a key card, and I ah--have never used them in the library except go up to them and get scared, and I would rather go and just ---I would even just walk around the library until I've found the books in the sections without the numbers---so I did computers--- as a course to overcame the fear of them but I hated it, so naturally they let me do what I wanted to do, not data bases and all that---

I. So did you like this program?

S. I did! This what I think computing, to me, is all about. Computing as far as doing spreadsheets and stuff is not what I am interested in and I will never do it because it is boring. But to use a computer creatively like this, so that I can get, express my words ---ahm---I think is wonderful.

I. So It has really helped you with this essay?

S. Yea. Because if I was writing about, essay, I am really slack in my writing and my thoughts get very confused and I very poor at spelling and I am not good at grammar either---afterwards I am OK, thinking "Oh that can have a comma" but usually I am too lazy and I think "Oh stuff it" and I will just hand it in. ---ah--- but here--- I think that because I am not very neat too, my writing is not very neat, it's not very attractive, but this is attractive.

I. Yes. It is.

S. So I get very proud of my work and then I put in the little extra touches.

I. Yes I noticed that with the other subjects, once they saw their work presented, you know, it looked good and they wanted to do more and more.

S. It looked good, you feel very proud. Yea, Yea and you feel you want to change a few extra words just to make it a bit more snappy.

Interruption---the end

HUMAN MOVEMENT

Human movement involves momentum. Momentum is defined as the amount of the mass times the velocity of the body in question. The scientific formula used for momentum is p=m.v. The symbol p, stands for momentum and is expressed in kilogram metres per second. Momentum is never lost or destroyed but is simply transfered from one object to another. This is the law of conservation momentum and is illustrated in the following examples.

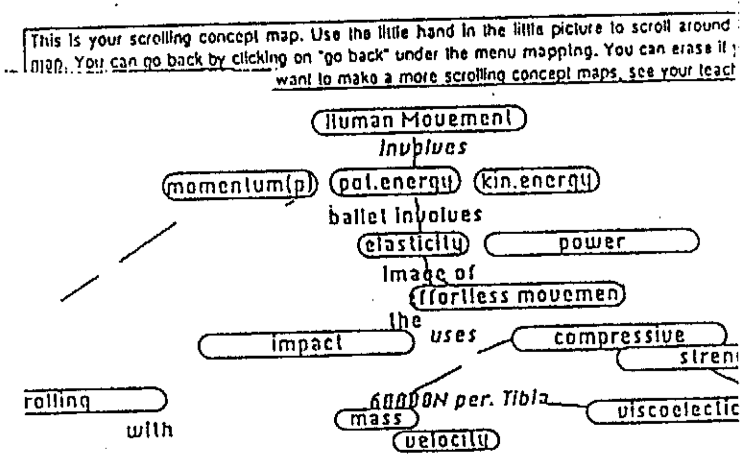
An example is to observe the meeting of two iceskaters, one moving, the other stationary. The moving iceskater will, upon meeting the stationary skater will have the momentum shared between them. So by vector addition the law is proven that "m.v" of the first plus "m.v" of the second is the total sum of momentem.

This law of momentum provides much delight to the participants and is used to thrill audience's and impress judges when used creatively in competitions.

For any movement to take place energy must be present. Energy is a scalar quanity and appears in many forms; electrical, chemical, nuclear and mechanical. The body system uses chemical energy to convert food into energy for cellular functions.

Human movement deals with mechanical energy involving both potential and kinetic energy. A snow or grass skier has potenial when standing on top of the mountain slope. He has his weight and gravity (9.8sec.squared), times the height of the slope. This is his potenial energy as he embarks down the slope and changes it into kinetic energy, the energy of motion.

Kinetic energy depends on the skiers velocity, the formula used to measure this energy is KE=1/2 m.vsquared. The energy produced depends on the speed the skier can obtain. The greater the speed the energy created



Appendix 6.6
First extended study post-SLDP teacher survey form

This questionnaire was administered to assess teachers' opinion about the assessment of writing in physics and the value of the components of SLDP after they had used it.

SLDP TEACHER SURVEY

PART A

1. How many students do you have in Year 11 Physics? 8

   How many of them are having difficulties with:

   (a) gaining S for the WBLA 2

   (b) understanding the Physics texts 2

   (c) writing essays up to Yr 11 standard Physics 2

2. In what ways does the WBLA/SACE help students to write Physics? It only ensures that students have opportunities to write in physics but not (in itself) help the students to write physics.

3. In what ways (if any) do you find WBLA/SACE a disadvantage? Occasionally too much time is wasted on activities designed for objectives to be met when I would rather be developing understanding of concepts and/or teaching to a greater depth in topic areas.

4. Do you think the SLDP would improve your students? Yes

   How? The method used helps students to develop a constructive approach to writing an essay. This is of great assistance itself.

5. (a) Do you use an itemised style of assessment as in SLDP? NO

   (b) If not how do you assess essays? Only a small portion of the ~~marks are~~ allocated to the structure of the essay. Most marks are awarded to the content.

   ? (b) Would you give any item have more weighting?

   (c) Would you add other items to the assessment criteria?

Other comments about the SLDP? It requires a dedicated teacher to allow more time in their lessons to be used on [redacted] teaching and assisting students with this approach to writing. SLDP should be introduced already in junior science courses eg year 10.

PART B

Now that you have taken your students through the SLDP!
1. How did you rate the effectiveness of these strategies
none------a little------some------high--------very high

(a) concept mapping ---high---

(b) reading texts ---~~some~~ high---

(c) writing models → model essays? ---~~high~~/some---

2. How did you rate the effectiveness of the L.1 -12 lessons

(a) elementary sentence construction ---high---

(b) paragraph writing ---high---

(c) genre and language register of science ---Some---

3. How do you rate the Physics learning in this topic? ---high---

4. Would you use the SLDP (in its shortened form) again?--yes--

5. In what ways could it be improved?--I would need much more detail on elementary sentence construction and information on how to teach or deliver these aspects to a class.

6. Did you detect any differences in its use between girls and boys? N/A

7. Do think the students enjoyed SLDP? Which aspects?--Yes (1) It was enlightening for them to be given the skills of concept mapping from which to write an essay (2) The students liked using the computers and having model essays available/and reading texts.

8 Please comment on any further aspect of the two week trial?---

---

---

9. Thank you for your assistance.

Appendix 6.7a

First essay of a student with poor language skills

Appendix 6.7b

The corresponding concept map

Appendix 6.7c

Descriptive assessment of the same student's second essay

Car Stopping

The cars stopping can be braking collisions No Petrol. *This is not a sentence.*

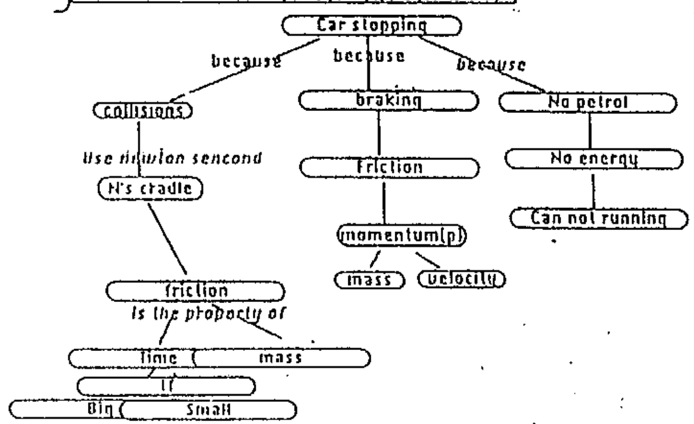
First thing I am going to discussed Cars braking. The Cars run on the road when the traffic light turns to red colour the cars should stop before the Zebra Crossing. The cars usually can not stopping as soon as it breake breaking they may going one distance and then stop. Because running's cars has acceleration. When car braking the acceleration equal zero. *This is not a sentence* So how far the car going after its breaking equal initial speed time "t". *will continue is dependent upon time "t".*

The car's collisions can make the car stop because Newton's second law show us: If an object exerts a force on another object (action) force, there is an equal force in the opposite direction from the second object onto the first (reaction force) for the same amount of time. So when the car hits something the thing will give the force to the car the same impulse in the opposite direction to car. This force exerts are important in time, if the time short the force become higher if the time long the force becomes smaller. The another thing is when the car hitted something. There are have energy between the car and the things. Where are the energy after collisions? The energy may turn to noisy, damage to the car or the thing.

You are going well

Incomplete. Only half so far.

This is your scrolling concept map. Use the little hand in the little picture to scroll around the map. You can go back by clicking on "go back" under the menu mapping. You can erase it you ... you want to make a more scrolling concept maps, see your teacher.



CAR STOPPING

In our socelty people driver the car, this a hight technology form to used, the people makes car can be brakes, the cars stopping car because by braking, collisions and No petrol.

First thing I am going to discuss is cars braking. The car run on the road and when the traffic light turns to red colour the car shout stop before the zebra Crossing. The cars usually car not stop as soon as it breaks breaking and they may go further before stopping because runing's cars has acceleration. When a car braking the acceleration is reduced to zero. So how far the car will continue is dependent upon time "t"

It car's collisions can make the car stop because Newton's law show us: If an object exerts a force on another object (action) force, there is an equal force in the opposite direction from the second object onto the first (reaction force) for the same amount of time. When the car hits something the thing will give the force to the car the same impulse in the opposite direction to the car. This force exerts are important in time, if the time short the force become bigger, if the time is longer then the force becomes smaller. The another thing is when the car hits something. There are have energy between the car and the things. Where are the energy after collisions? the energy may turn to nois, damage to the car or the thing.

The cars are runing because car has energy, we know the energy may change to monentum. For example a person had foods and the foods change to energy for that person to living, so that person can doinmg something eg to runing, walks and play some activity. So the cars are simlar like people. The car works may spent a lot of energy. Where are car's energy from? Also the cars has "own food" as petrol. If the cars has not energy, cars can not runing.

There are many effect can make car stop, so on view of car stop we must think the car may have no petrol as given energy. the car may had collision to main car stop, the another thing is the car may had braking to stop car.

South Australian College of Advanced Education **Memorandum**

Date 8/9

From

To

I think Hao knows many things about communication in general, the English Language in particular and about his topic.

He is aware of the need to structure what he wants to say and the essay has an intro, a development section and a conclusion (although he uses the conclusion as a repetitive summary). The development of his ideas is the best part of his essay because he displays a clear understanding of principles of Physics and illustrates his understanding with examples and interesting questions. His knowledge of theory and practical application are communicated, as well as the fact that he is thinking about related issues.

He can spell some difficult words (eg "usually", "acceleration", "collisions"). Some of his attempts to spell are phonetic (or typos?) eg "impalse" "soceity" and "monentum", and he is understandably confused about "brake" and "break". These are acceptable attempts to negotiate meaning.

Tense of verbs causes him problems and punctuation is a large pitfall. Can he read his work aloud? If so, he may be able to "translate" pauses for breath and falling intonation into commas and full stops.

I really like the sense of "engagement" with his topic (and his enthusiasm) which I got from reading this piece. MP

Appendix 6.8

New Arrivals Program (NAP) teacher's comments

These were written after the teacher had used three modules of HCP with three different classes of NAP students.

SLDP TEACHER SURVEY

PART A

1. How many students do you have in Year 11 Physics? ---------
   How many of them are having difficulties with:
   (a) gaining S for the WBLA ---------

   (b) understanding the Physics texts Majority of the students

   (c) writing essays up to Yr 11 standard Physics ---------

2. In what ways does the WBLA/SACE help students to write Physics? Only if teachers are prepared to explicitly teach New Arrivals how to write, then students will benefit much and learn a great deal from their writing.

3. In what ways (if any) do you find WBLA/SACE a disadvantage?

   NESB students are disadvantaged in that most teachers do not provide examples/model samples of writing. New forms of writing need to be discussed/analysed and features characteristic of particular forms of writing need to be identified and talked about

4. Do you think the SLDP would improve your students? Yes
   How? Explicitly teaches the students how to write in Science. Explicitly demonstrates the range of genre that can be used in Science Writing (P.T.O.)

5. (a) Do you use an itemised style of assessment as in SLDP? No – but will think of how to assess writing using a similar style

   (b) If not how do you assess essays? Assess According to SNAP guidelines – Structure and Organisation, Language Features, Accuracy

   (b) Would you give any item ~~have~~ more weighting? ---------
   This is related to the purpose of the writing task

   (c) Would you add other items to the assessment criteria? -----

   No

Other comments about the SLDP? The students could be given opportunities to change their concept map as they are writing their essay – This reflects the writing process, as drafting and editing often improves on first/original plan/concept map.

PART B

Now that you have taken your students through the SLDP!
1. How did you rate the effectiveness of these strategies
none------a little------some------high--------very high

(a) concept mapping ---high---

(b) reading texts ---Some---

(c) writing models --- — --- (not covered)

2. How did you rate the effectiveness of the L.1 -12 lessons

(a) elementary sentence construction --- — --- (not covered)

(b) paragraph writing --- — --- (not covered)

(c) genre and language register of science --- — --- (not covered)

3. How do you rate the Physics learning in this topic? ---Some---

4. Would you use the SLDP (in its shortened form) again?---Yes---

5. In what ways could it be improved?---Re NESB students – they need time to research/assimilate information and share their findings (orally)
Next time I would like to spread the SLDP over a period of 4-5 weeks rather than 2-3 weeks

6. Did you detect any differences in its use between girls and boys? No

7. Do think the students enjoyed SLDP? Which aspects?---Overall, the students found essay writing difficult as this was their first attempt at essay writing in Science. However, it was most beneficial.

8 Please comment on any further aspect of the two week trial?---
Most of the NAP students were pressured for time, especially the two level 5 classes studying Australian Studies Stage 1.
Consequently not enough reading in Science was done at home. The students attended lessons with not sufficient information input and as a result were stuck for ideas, or did not have a clear understanding of reading.

9. Thank you for your assistance.

P.T.O.

(4) Emphasizes the <u>importance</u> of a variety of skills involved in writing

eg determining the genre that is most appropriate (to

brainstorming ideas

organising ideas ⟶ concept map

reading and note taking relevant to topic

sentence construction (correct grammar use, spelling a

paragraphing (each paragraph contains one/two main ideas and a topic sentence

structure of essay — introduction (outline main i
main body
conclusion (summing up

drafting + editing

Emphasizes the <u>importance</u> of using own words rather (including technical terms) than copying from books.

Also students gained many skills in operating a McIntosh computer

I found the program <u>user-friendly</u>.

(8) It's much easier to write when your head is full of information and ideas which you understand and feel able to communicate to others. This was not the case with most of my students. Therefore more time would be spent seeking and reflecting on information, and more time (next time) could be spent composing and expressing their ideas.

Appendix 6.9

A list of essay writing tasks for the explanation genre

This list resulted from the recommendation of the first extended study that writing tasks be assigned in the explanation genre and a list of suitable writing tasks in various topics be given to teachers.

SCIENTIFIC LITERACY DEVELOPMENT PLAN (SLDP)
Can I ask for your assistance again in 1993?

For valid comparisons I need a series of up to 6 essays. The essays need to be of the one type, that is the explanation genre, aimed at fulfilling objectives in domains 3 and 4 of the SACE extended subject frameworks. Research assignments, lab reports, and biographies are good and necessary to meet a number of SACE objectives, but they are not satisfactory for measurement of students' writing in science ability at which the SLDP is aimed. Could you include essays similar to the ones in the following list in your assessment plan for 1993?

Some suggestions for Explanation Genre essays

Explain the role of experimentation in science. Use examples to show how experimentation has led to new theory or new knowledge.

Explain how the some inventions of science have contributed to the improving the quality of people's lives.

In what ways has magnetism played a part in the history of humans (and animals) and how do magnetic fields affect the way that we live today?

Explain the origin and bands of electro-magnetic radiation and say how these bands of radiation affect our lives.

Explain the difference between AC and DC and describe the use of each form of electricity.

Explain how AC and DC are generated and how circuits make it possible to use electricity in many appliances. Include safety devices.

Explain the different types of noise pollution and how this affects people.

Explain the necessity of caring for and looking after the sense of hearing from youth to elderly life.

Explain how different instruments produce different qualities and tones and compare these with the human voice.

How would you explain to a person (a child or an a elderly person) the cause of gradual blindness and what remedies may be discovered in the future for this condition.

Describe and explain Thomas Young's double slit experiment with light Discuss the significance of this experiment in our understanding of the nature of light.

How does the eye compare to human-made devices for the reception of light?

Safety is not related to how fast you go but how fast you stop. Discuss.

Seatbelts are a practical response to Newton's laws of motion. Discuss.

Explain how sport is a direct application of Newton's Laws.

Discuss how human movement in sport and work depends upon the principle of conservation of energy.

Explain how the designers of cars should keep in mind the principle of conservation of momentum when designing the interior and exterior features of cars.

Describe the work of a radio therapist. Explain the Physics involved in this occupation.

Explain how the human body is dependent on heat energy and the ways in which we maintain that heat energy.

My suggestions for implemenrtation are as follows:

- 2 weeks notice of writing assignment
- 1 class lessons for the writing (typing) of each essay
- validation that all essays are the students own work, no copying even from references.
- SACE objectives in domains3 and 4
- the essays are formative, so that teacher assistance is legitimate, but not teacher correction of drafts. They may be used by you summatively, and even by the students for WBLA, but my purposes will be served if the students take them seriously say for example for marks within your marking scheme, even if not for SACE.

Finally the extra data I need will be by the same as for this year local area dwelling (map), TORCH comprehension, WBLA grade RNM/S, English language background, student surveys after SLDP, teacher surveys after SLDP.

Thank you I hope you can help.

Appendix 7.1

Teacher's course schedule

This is a copy of one teacher's course schedule incorporating SLDP into a number of topics in the Year 11 course. The course schedule indicates the students would use HCP modules in:

* Electricity topic in weeks 3 and 4;
* Electromagnetism topic in week 7;
* Heat Transfer topic in week 14;
* Radiation topic in week 15;
* Nuclear Radiation topic in week 17.

Physics Stage 1
Course Outline

Semester TWO Assessment Plan 1993

Topic	Key Concepts	Assessment Activity	Objectives Assessed	Comments
Electricity	**Week 1** Conductor Circuit Closed circuit Terminals Open circuit Short circuit Series connection Parallel connection Switch	**ITEM 1 Presentation: JOURNAL ARTICLES** **Journal material** **Students are to collect at least three articles on electricity from newspapers or magazines and present a summary of each of these. The articles must be 1. an application** **2. career path & fields** **3. use of physics knowledge** **(No more than 100 words / article)** ***This must be written in essay form and have a concept map.*** **[Due week 4]**	1.3, 3.1, 3.2,3.3, 4.2, 4.3	**WBLA** Students will have 3 weeks to complete this assignment.
	Week 2 Circuit diagrams Electric current Conventional current Potential difference emf Resistance	Experimental Report Students are to construct given circuits from circuit diagrams and be able to operate an ammeter, voltmeter or multimeter to determine current and potential difference in various circuit paths. Experimental report Ohm's Law Refer to Exp. 12.1 from Physics One teachers Guide. "Plotting V and I characteristics" [Due week 3]	*1.2, 2.1* *1.2, 2.1*	Student should be given ample opportunity to observe and interepret a variety of circuit diagrams.

Semester TWO Assessment Plan 1993

Topic	Key Concepts	Assessment Activity	Objectives Assessed	Comments
Electricity	**Week 3** Science Language Development.	Students will work in the Macintosh room with the Hypercard program preparing ITEM 1 <u>JOURNAL ARTICLES</u>		
	Week 4 SLD Continued	Students will work in the Macintosh room with the Hypercard program prep: ring ITEM 1 <u>JOURNAL ARTICLES</u>		
	Week 5 Energy Energy conservation Energy transformation	<u>Short written test</u> Multiple choice test where students identify circuits and appliances that transfer energy into different forms. <u>Context One Questions</u> Questions 1 - 21 Pages 359 - 360 Students can refer to answers in the reference section of the Library	2.2, 2.3, 4.1 2.1, 2.2 ,2.3, 4.1, 4.2	 Marked on a 0 - 2 scale where : 0 = not completed 1 = satisfactory 2 = above average Some answers to questions discussed in class.
	Week 6 Power Fuse Circuit breaker	<u>Assignment</u> Compare the cost of cooking a meal using a conventional hotplate with the cost of microwave cooking : students calculate energy usage based on appliance power ratings and recorded "power on" times. <u>Written test</u> Students are to answer a variety of simple calculations involving circuits, voltages, current, resistance, power and transfer of energy.	1.2, 1.3, 2.1, 2.2; 2.3, 3.1 2.1, 2.2, 2.3, 4.1	Students to present collection of articles and summaries this week.

Semester TWO Assessment Plan 1993

Topic	Key Concepts	Assessment Activity	Objectives Assessed	Comments
Electromagnetism	**Week 7** Magnetic domains Magnetic field Direction of magnetic field Magnetic pole Magnetic field line SLDP Brushes Field coil Commutator Armature Solenoid Electromagnet Magnetic induction Soft iron	<u>ITEM 2 Experimental design & Report:DC ELECTRIC MOTOR</u> **Students are to construct a DC electric motor & design and conduct an investigation into the efficiency of their electric motor. [Due week 8]** Experimental report MUST be written using Hypercard. Procedural Genre	1.1, 1.2, 2.1,	Students will be provided with an electromagnetic kit for which they are responsible. The kit will contain all the necessary requirements for the experiment and efficiency investigation.
	Week 8 Magnetic force Normal Turning effect			

Semester TWO Assessment Plan 1993

Topic	Key Concepts	Assessment Activity	Objectives Assessed	Comments
	Week 9 Magnetic flux An increasing field A decreasing field Area of a coil	<u>Notes on film</u> "Magnetism"	*1.3*, 3.3, 4.1, *4.2*	
	Induced emf Induced current	**<u>ITEM 3 Written test</u>** **Students should be able to interepret a series of diagrams of magnets , electromagnets, e.t.c. to determine field lines, polarity and direction of conventional current.**	2.2, 2.3, 4.1	
	Week 10 Matter Solid Liquid Gas Brownian motion			

Semester TWO Assessment Plan 1993

Topic	Key Concepts	Assessment Activity	Objectives Assessed	Comments
Heat	**Week 11** Temperature Energy	<u>Oral Presentation</u> Students are to select from : • Heat and the human body ; animal adaptations, temperature changes e.t.c. • Home cooling and heating systems ; Evaporative & refrigerative air conditioners, reverse cycle air conditioners e.t.c. • Heat & the Earth's Atmosphere ; temperature variation, the effect of latitude e.t.c. (Refer to "Physics One" Heating and cooling) This can be completed as a major project where students have the choice in presenting their findings in a number of different ways ; Oral presentation Cassette Video Computer	*1.3*, 2.1, *3.1*, *3.2*, 3.3, *4.3*	
Heat	**Week 12** Heat Capacity Specific heat capacity	<u>ITEM 4 Experimental Design & Report:SHC</u> **To determine the specific heat capacity of various liquids and metals e.g. water, milk, olive oil, iron copper, brass and compare to literature values.**	1.1,1.2, 2.1	

Semester TWO Assessment Plan 1993

Topic	Key Concepts	Assessment Activity	Objectives Assessed	Comments
Heat	**Week 13** Latent heat Latent heat of fusion Latent heat of vaporisation	<u>Experimental Design & Report</u> Students are to design an experiment to determine the latent heat of vaporisation of water and conduct the investigation to determine its value. (refer to "Physics : an examination course".)	*1.1, 1.2,* 4.3	
		<u>Context One Questions</u> Questions 1 - 35 Pages 86 - 87 Students can refer to answers in the reference section of the Library	2.1, *2.2* ,2.3, 4.1, 4.2	Marked on a 0 - 2 scale where : 0 = not completed 1 = satisfactory 2 = above average Some answers to questions discussed in class.

Physics Stage 1
Course Outline

Semester TWO Assessment Plan 1993

Topic	Key Concepts	Assessment Activity	Objectives Assessed	Comments
Heat	Week 14 Heat Transfer	<u>ITEM 5 Written test</u> Students solve a variety of numerical problems dealing with specific heat capacity, latent heat of fusion & latent heat of vaporisation.	2.2, 2.3, 4.1	
		<u>ITEM 6 Presentation:ENERGY EFFICIENT HOME</u> Students may present a plan or model of an energy efficient home. Students will need to consider : - direction rooms are facing. - providing shade to the appropriate areas. - number of windows facing a particular direction. - planting trees for shade - insulation (walls, roof and windows ?) - grass vs concrete for the outside. (Energy information center can provide for much help) [Due week 17] * *Students will spend FOUR lessons this week completing the Science Language Development component.*	3.1, 2.1, 3.3, 4.3	**WBLA** Students will have one week with which to produce a first draft and a final copy.

Semester TWO Assessment Plan 1993

Topic	Key Concepts	Assessment Activity	Objectives Assessed	Comments
Radioactivity	**Week 15** Radiation	<u>Written Assignment</u> Report on the work of a radiolotherapist or any other person undertaking activities involving ionising radiation. * *Refer to Science Language Development Program.*	1.3, *3.1*, *3.2*, *3.3*, 4.2	
	Ionisation	<u>Context One Questions</u> Questions 1 - 18 Page 142 Students can refer to answers in the reference section of the Library	2.1, *2.2* ,2.3, 4.1, 4.2	Marked on a 0 - 2 scale where : 0 = not completed 1 = satisfactory 2 = above average Some answers to questions discussed in class.
		<u>Context Two Questions</u> Questions 1 - 18 Page 142 - 143 Students can refer to answers in the reference section of the Library	2.1, *2.2* ,2.3, 4.1, 4.2	Marked on a 0 - 2 scale where : 0 = not completed 1 = satisfactory 2 = above average Some answers to questions discussed in class.

Semester TWO Assessment Plan 1993

Topic	Key Concepts	Assessment Activity	Objectives Assessed	Comments
Radioactivity	**Week 16** The atom Atomic number Mass number Isotopes Alpha, beta, gamma & X - radiation.	Oral presentation The advantages & disadvantages of using radioactive substances. (Social, political & econimical pressures) This may be conducted as a debate in class, where each student may : - present a fact or evidence - rebut an arguement - develpop an arguement	2.1, *3.1*, *3.2*, *3.3*, *4.3*	
	Half- life	Context One Questions Questions 1 - 35 Page 166 - 167 Students can refer to answers in the reference section of the Library	2.1, *2.2* ,2.3, 4.1, 4.2	Marked on a 0 - 2 scale where : 0 = not completed 1 = satisfactory 2 = above average Some answers to questions discussed in class.
	Week 17 Electrostatic Force Nuclear Force	** Students will spend FOUR lessons this week completing the Science Language Development component.*		
	Nucleon Nuclear stability Conservation of energy	Notes on video "Nuclear Physics"	*1.3*, 3.3, 4.1, *4.2*	

Semester TWO Assessment Plan 1993

Topic	Key Concepts	Assessment Activity	Objectives Assessed	Comments
Radioactivity	**Week 18** Mass defect Fission Fusion	<u>Written Test</u> Students solve a variety of numerical problems involving the use of Einstein's mass - energy equivalance equation and write simple chemical formula for reactions. <u>Semester Examination</u>	*2.2, 2.3, 4.1* *2.1, 2.2, 2.3, 4.1*,1.3	

Stage One Physics

Objective	Criteria for Judging Satisfactory Performance	School Assessment
1.1	Write a logical plan for obtaining information or data. Such a plan would include; • Identification of aim or purpose • Identification of key components/apparatus/techniques. • Specify variables • Identify sources of error	Students will need to score 59% or above.
1.2	Complete practical activities and submit a practical report. The practical report should contain : • An appropriate method of displaying raw data. • A conclusion based on the observations.	Students will need to score 59% or above.
1.3	Use a variety of sources from which to extract information and document these in an appropriate manner. Present materials from different media in the appropriate form.	Students will need to score 59% or above.
2.1	To analyse data and provide for a critical evaluation of the observations. Be able to provide for a short synopsis of what has been learnt from each experience.	Students will need to score 59% or above.
2.2	Be able to demonstrate a knowledge of a range of key ideas and an understanding of physics concepts and laws.	Students will need to score 59% or above.
2.3	Be able to solve a variety of problems.	Students will need to score 59% or above.
3.1	Be able to identify and discuss a research topic in physics and be aware of its 'everyday' application.	Students will need to score 59% or above.
3.2	Be able to investigate the life or work of a physicist or person undertaking an activity which uses physics knowledge.	Students will need to score 59% or above.
3.3	Be able to identify careers in physics and their respective fields.	Students will need to score 59% or above.
4.1	Be able to use physics terminology and notation.	Students will need to score 59% or above.
4.2	Be able to produce a written summary (appropriate in length) of the key ideas presented in a video or a computer program to produce notes or present graphs or concept maps.	Students will need to submit their notes etc at the end of the lesson
4.3	Be able to communicate physics concepts in a creative way : poster, video, cassette or by other means.	Students will need to score 59% or above.

Assessment 1993

Stage One Physics

Assessment Plan 1993

FULL Year Course

Topics	Item No.	Summative Assessment Items	Work Due	Objectives: Acquiring Knowledge 1.1	1.2	1.3	Understand & problems 2.1	2.2	2.3	Use 3.1	3.2	3.3	Communicate 4.1	4.2	4.3	WBLA
Semester One																
Linear Motion	1	Exp.design & report :Estimation of 'g'	5	√	√		√									
	2	Presentation: Physics & technology	7			√				√	√	√		√	√	√
Dynamics	3	Written Test	8					√	√				√			
W / E / P	4	Presentation: Sports Science	12			√				√	√	√		√	√	√
Light Rays	5	Exp.design & report :Refractive Index	13	√	√		√									
Waves	6	Written Test	14					√	√				√			
Semester Two																
Electricity	1	Presentation : Journal Articles	4			√				√	√	√		√	√	√
Magnetism	2	Exp.design & report :DC Motor	8	√	√		√									
	3	Written Test	9					√	√				√			
Heat	4	Exp.design & report :SHC	13	√	√		√									
	5	Written Test	14					√	√				√			
Radioactivity	6	Presentation : Energy Efficient Home	17			√				√	√	√		√	√	√

Stage One Physics

Keep this document for your own record of achievement

Topics	Item No.	Summative Assessment Items		Work Due	Objectives												WBLA
					Acquiring Knowledge			Understand & problems			Use			Communicate			
					1.1	1.2	1.3	2.1	2.2	2.3	3.1	3.2	3.3	4.1	4.2	4.3	
Semester One																	
Linear Motion	1	Exp.design & report :Estimation of 'g'		5	√	√		√									
	2	Presentation: Physics & technology		7			√				√	√	√		√	√	√
Dynamics	3	Written Test		8					√	√				√			
W / E / P	4	Presentation: Sports Science		12			√				√	√	√		√	√	√
Light Rays	5	Exp.design & report :Refractive Index		13	√	√		√									
Waves	6	Written Test		14					√	√				√			
Semester Two																	
Electricity	1	Presentation : Journal Articles		4			√				√	√	√		√	√	√
Magnetism	2	Exp.design & report :DC Motor		8	√	√		√									
	3	Written Test		9					√	√				√			
Heat	4	Exp.design & report :SHC		13	√	√		√									
	5	Written Test		14					√	√				√			
Radioactivity	6	Presentation : Energy Efficient Home		17			√				√	√	√		√	√	√

Appendix 7.2
Supplement to the Teachers' Manual

This supplement to the Teacher's Manual enables teachers to modify the spelling checker, the grammar checker and the document statistics counter of the HCP modules.

TEACHER'S MANUAL SUPPLEMENT

A. To alter the Spelling checker:

1. Type "command M"
2. Blind type "set userlevel to 5"
3. In the message box type 'Show card field "correct" '
4. In the correct alphabetical listing, type in the required words, separating each with a comma.
5. Check that each group of words in the alphabetical listing ends in a "9"
6. In the message box type 'Hide card field "correct" '
7. Close the script and close.

B. To alter the grammar checker:

1. Type "command M"
2. Blind type "set userlevel to 5"
3. In the message box type 'Show script of card button "Grammer" '
4. Copy from line "on numberten to "end numberten"
5. Paste the copy in before "on numberten"
6. Alter the copied "numberten to "numbertwelve" (or thirteen etc) at each location
7. Type "numbertwelve (or thirteen etc) in the "on mouseup" section at the beginning of the script
8. Type " (required word) zz" for "its zz"
9. Type the corrected word into the line "do you want this word to be (corrected word) ?"
10. Then type the corrected word into the "yes" question: "put (corrected word) into the foodchunk"
12. Close the script and close.

B. To alter the document statistics counter:

1. Type "command M"
2. Blind type "set userlevel to 5"
3. In the message box type 'Show script of card button "Counter" '
4. Copy a section of script from "if" to "end if"

5. Paste the section of script immediately after the last "end if"

6. Alter the new section according to the required ratio or count giving the new section a new name

7. Insert the new name in the globals in line one of the script

8. Type in a new question using the new name

9. Close the script and close.

Appendix 7.3a

Second extended study post-SLDP student survey form

This questionnaire was used to gauge students' opinions about their attitude to writing in physics compared with other subjects and if they found that writing in physics was enjoyable. The same questionnaire was administered to both Experimental and Control group students.

SLDP STUDENT SURVEY '93

Do you find it easier to write essays in physics or english?
Physics ✓ English___ Neither___ Both the same___

What was the reason for your answer in Q.1?

Because we set up the concept map first, then we base on the concept map to write the essay

What do you think the differences are between the style of writing essays in englis id physics?

In physics we have to write in term of physic

. How much do you think reading other than text books, helps in writing essays in hysics?

more information

nd in english?

---

5. Have you found the writing of essays in physics enjoyable this year? (TICK)
not at all---- a little----some---- quite a lot-✓-very much---

Thank you.

Appendix 7.3b
Second extended study post-SLDP teacher survey form

This questionnaire was the same as that administered after the first extended study. It was used to confirm earlier results and to gain new suggestions for improvement of the program.

SLDP TEACHER SURVEY

PART A

1. How many students do you have in Year 11 Physics? 25
   How many of them are having difficulties with:
   (a) gaining S for the WBLA 1

   (b) understanding the Physics texts 3

   (c) writing essays up to Yr 11 standard Physics 4-5

2. In what ways does the WBLA/SACE help students to write Physics?

Unless sufficient time given to appropriate tasks, it can be stressful for students.

3. In what ways (if any) do you find WBLA/SACE a disadvantage?

Students are prone to copy from texts as examples of WBLA – it should not be encouraged

4. Do you think the SLDP would improve your students? Yes
   How? Forces them to organise ideas, link here concepts a make construction of their essay before taking place

5. (a) Do you use an itemised style of assessment as in SLDP? Yes

   (b) If not how do you assess essays?

   (b) Would you give any item have more weighting?
   Content – concepts related to topics

   (c) Would you add other items to the assessment criteria?
   ?

Other comments about the SLDP? It has forced me to look at the WBLA tasks given so far in Stage I course

Appendix 7.3b

PART B

How that you have taken your students through the SLDP!
1. How did you rate the effectiveness of these strategies
none------a little------some------high--------very high

(a) concept mapping - high

(b) reading texts Some.

(c) writing models unsure

2. How did you rate the effectiveness of the L.1 - 12 lessons

(a) elementary sentence construction my students didn't really need this

(b) paragraph writing Some

(c) genre and language register of science Some

3. How do you rate the Physics learning in this topic? unsure

4. Would you use the SLDP (in its shortened form) again? at a different point in the topic

5. In what ways could it be improved? Some of the concepts used in electricity at Yr11 level would not normally be covered (eg)

6. Did you detect any differences in its use between girls and boys?
No – not really

7. Do think the students enjoyed SLDP? Which aspects? Yes
not a chalk/talk lesson

8 Please comment on any further aspect of the two week trial?---
Unfortunately, it does cut into teaching time, even though students are learning about the concepts at the time. This fear would be reduced when Stage 2 course content made more realistic.

9. Thank you for your assistance.

Appendix 7.4a

Classroom interaction analysis

This is an analysis of a typical classroom interaction with the corresponding transcript in one 40-minute lesson.

Appendix 7.4b

Computer room interaction analysis

This is an analysis of a computer room interaction with the corresponding transcript in one 40-minute lesson.

Classroom Interaction Analysis

Language function[1]	Interaction dialogue	Legend	Initiated by teacher	Initiated by students
Ideational	Use of concepts	*	13	4
	Relational statements	#	11	6
	Applied examples	@	6	5
Interpersonal	laughter, moving around, student interaction	Φ	1	2
Textual	OHP, drawing diagrams, writing, demonstrations	φ	4	-

Setting Thematic Patterns[2]	Legend	Frequency
Teacher question & answer series	TQA	2
Teacher question, elaboration and modification series	TQE&M	5
Joint construction	JC	3

1. Malcolm, I. G. (1986)
2. Lemke, J. L. (1990)

Classroom Interactions

Fred's class (24 students): Magnetism

Time and routines	Teacher dialogue	Student dialogue	Thematic Patterns
12.20am	Introduction to magnetism		
First sub-routine	OHP:		
	magnetism, lodestone*		
	compass)		
	coulomb) @		
	inverse square law #		
	attraction (gravitation) @		
	attraction and repulsion*		
	$F = 1/d^2$ inverse square law #		
	Vary the force (with distance)		
	Q: To double the force? #	It would be less) ....half) # ....quarter)	TQA
	Q: Three times the distance?	decreases by a ninth #	
	Centre of mass, centre of field*		
	Q: How is this affected	It would be weaker	TQE&M
	Oersted		
	coil, compass needle		
	deflection of needle @		
12.35	magnetic effect *		
Juncture	BB: magnet is a material. φ	S's: WRITING	
Second sub-routine	ferromagnetic *		
	non-magnetic *		
	Two types of magnet permanent and temporary *	S's: WRITING	
	demagnetisation #		
	Q: Differences?	Fe an element, steel an alloy @	TQE&M
	electrons get aligned #		
	electron spin gives direction #		
	soft iron *		

	alignment of electrons *		
	disalignment #		
	Any questions?		
	OHP: charges		
	electrons		
	flow of charge *		
12.46	poles: north, south *		
<u>Juncture</u>	DIAGRAMS; bar magnet) φ	S's DRAWING	
Third	horseshoe magnet) @		
sub-	ring magnet)		
routine	TEACHER MOVES AROUND Φ	S's continue drawing	
		magnetic particles?	)
		or radiation *	)TQE&M
	No		)
		S: <=> S: splitting a	JC
		magnet @	
		S: ---	
	OHP: Unlike poles attract#		
	consider a isolated charge		
	dipoles *		
	non-separated		
<u>Juncture</u>	Any questions? φ		
12.58	DEMONSTRATION:		
Fourth	Earth's north *		
sub-	Q: How does NP point	because the magnetic	TQA
routine	north? @	north is north #	
	BB: compass needle @		
	magnetic fields		
	Q: How is energy shown?	See the work done by	
		energy	
		It's kinetic energy *	
	Q: force of attraction?	Kinetic energy *	
		between the iron and	
		the magnet	
	No, we are not talking	We can't see it	TQE&M
	about energy	(attraction) like other	
		forces we can't see	
	Meaning?	By the energy, you	
		can't explain it #	
		It's in the fourth	TQE&M
		dimension*	
		LAUGHTER Φ	

	Explain it in science	Something in the atoms #	
	Yes, a theory called the string theory		
	a particle between neutron and proton called a 'graviton'	But it may not be true	
		Is it like a plant that is sensitive to gravity @	JC
	In magnetic fields we see the effect of movement and force	So would a magnet lose energy?	
	It doesn't lose or gain	What about radiation?	
Juncture	There is interaction between field and speed of light #		
1.07	BB: DIAGRAM φ		
Fifth sub-routine	propagation in space #		
	magnetic field lines *		
		Could it (attraction) be like seeing a lady that makes you turn your head? Like a force? #	
		LAUGHTER Φ	
	OHP DIAGRAM:		
	Finding direction of field? #	Suspend a magnet @	
	Q,Q,Q	Iron dust on paper @	JC
1.15	END OF LESSON		

Computer Room Interaction Analysis

Fred's first class (26 students)

Language function[1]	Interaction dialogue	Legend	Initiated by teacher	Initiated by students
Ideational	Use of concepts	*	20	18
	Relational statements	#	9	9
	Applied examples	@	2	1
Interpersonal	Moving to another student	ϕ	1	8
Textual	Concept mapping, writing	φ	-	26

Setting Thematic Patterns[2]	Legend	Frequency
Teacher question & answer series	TQA	2
Teacher question, elaboration and modification series	TQE&M	1
Joint construction	JC	6

1. Malcolm, I. G. (1986)
2. Lemke, J. L. (1990)

First Computer Room Transcript

Fred's Class

Compare the eye and optical instruments in their use of light

STUDENTONE

Tϕ. That's the main topic is it? —and these are going to be the components?

S. Well that's what I wanted to know. I didn't know whether to have the things stuck in here or better having them coming out. φ

T. I think they would be better under components---yea---down this side then you can put a connecting word in, which says the eye* has a number of components such as---whatever and this is a response# to light*.

S---and its characteristics

T. ....which has the following characteristics

S---and the problems* of eyesight. I can also have them coming out, at the side of the eye concept and connecting them across here--- φ

T. Yes.

S. All right
(Joint Construction (JC) for setting thematic pattern)

SECONDSTUDENT

S.ϕ I am going to go with the nature* of light.

T. Yes.

S. The theory of light in waves*, then photons*--but with photons---can you go on with ---uhm--photons because I am doing the eye and ---uhm---glasses@. φ

T. Yes.

S. You said how I could express reflection* and refraction* through# wave theory, using the cornea* and lens. Can I just leave the photons, or is there anything I can leave on with photons. φ

T. Well we can't it use the idea of photons very much at this level. You would if you were using the photo-electric cell* for example.

S. So really you just have to explain# there are two theories, yes, and just go on to say that there is one better idea?

T. Yes that would be a good way to say it for the eye.

S. So I will go on with that?

T. Yes.
(Joint Construction (JC) for setting thematic pattern)

THIRD STUDENT

S.ϕ I have said that the critical angle* is--- where light is only refracted* but where light is I mean----I mean I made a mistake but I am trying to say---if I try and connect this up, do I say that this is --uhm--- total internal reflection*-- occurs# at, when the--, at the critical angle. φ

T. It occurs just past the critical angle, because when you have got the critical, and the light is coming in, there's the normal#, it wants to go out there, but when it gets to the critical angle, it goes along the surface, so if you're under the water@ looking up, you will see just the silvery effect* of going along the surface of the water, whereas if you make the critical angle a little bit bigger you will see the ray coming# from something reflected (under the surface) on the other side of the normal. So I would suggest these words might come down between those two concepts. What do you think?---If I were reading it, I would say "the critical angle is where the ray is no longer refracted (through the surface#) and that would lead into your total internal reflection idea. What do you think?

S. Yeah.

T. From there I would say something like "the ray can be incident at the critical angle". Use the word "incident". There, that's not a bad idea is it.

S. Does that mean that incident* means---coming in#---straight. φ

T. Incident means the ray coming in to the critical angle. After going through the critical angle you talk about what happens after---and explain that this reflection occurs# after the incident ray makes the angle and is refracted at an angle grater than 90°*.

S. Should I say that--uhm-- light is coming through# ---the critical angle?

T. Why not say light comes in at greater# than the critical angle---or light can be incident at the critical angle.

(Teacher question elaboration and modification of answer (TQE&M) for setting the thematic pattern)

STUDENT FOUR

S.ϕ Which concept do I have reflective* of refractive* (telescope)? φ

T. Why not use the two of them. Do one first. Do you want reflective or refractive what?

S. Refractive telescope*.

T. Oh -- OK. Now what do you want to put underneath 'telescope' or do you want to put it to the side for later comparison?

S. At the side. φ

T. OK. Now what's the other type of telescope. See you don't have to put the word telescope in again --- just connect it.

S. Oh yes, I see.

T. See if you can just draw a line from the telescope to refractive---

S. Oh, I see, yeah and I am going to do refractive first. φ

T. Yep and then reflective and then you can put in the connection.

S. Oh yea underneath. φ

T. Yes, good work.

S. And what about more about the law of refraction#, because I want to describe that, do I put it first, before or what? φ

T. I think it would go on the line, you know when you join the two of them together.

S. Oh all right. φ

T. The law shows the fact that you have already been describing reflective and refractive telescopes.
(Joint Construction (JC) for setting thematic pattern)

STUDENT FIVE

S.ϕ Can you help please.

T. OK. Have you got your name on the top of this?

S. OK---on the top? φ

T. Yea.

S. Did you change the shape of this? Do you know what you are doing. I'll show you if you like. Do you want to get back to where you started? φ

S. Yes I wanted to ask you about my essay. What is that thing---It's on my essay. φ

T. That's the concept. You can move it, delete it, change it's shape—

S. That's what I want--- φ

T. That's light. Is that what you want? Go through the menu--new concept-- now put in your words.

S. That's what I want. Oh yes--with the mouse. φ

T. That's light. Now you can draw it.
(Teacher question and answer (TQA) for setting the thematic pattern)

STUDENT SIX

S.ϕ When I was talking about light coming actually through the eye, I want to have this dual nature*, down here.

T. Well I think you have got to combine both. What are the characteristics* of light, which say occur at the lens, --obviously refraction.

S. OK.

T. What are the characteristics of light that occur at the optic nerve* or at the retina*. It is going to involve the concept frequency* isn't it?---so that's the colour* is picked up by the optic nerve. So for each characteristic link it across here to how it is picked up by the eye.

S. So introduce them (retina, optic nerve, frequency) in each paragraph and talk about it? φ

T Yes---so you can see the differences.

S. — and join them up? φ

T. Yes. One person's essay@ will have just (only) all these things listed down, and then in the next paragraph they will say all this (the effect on the eye). But a better essay is when someone links them up to the characteristics of this---and its linked concept and so forth. See how you go on that.

S. So should I link# the (optic nerve) and colour. φ

T. Yes and the other. Link them like this in your essay.
(Joint Construction (JC) for setting thematic pattern)

STUDENT SEVEN

S.ϕ First the parts of the eye here, and the iris*--and waves* here, and then my second paragraph?

T. Where's your second paragraph--is it going to be about waves, is it?

S. Yes eyes are there ---

T. Sorry I didn't catch what you were talking about over here. φ

S. Actually I am getting a new one called waves but waves come# into the eye.

T. So would you put it in there. Isn't that all about different theories about particles* and photons?

S.--------

T--------

S--------

T. I think your idea of connecting them is good but it's the eyes that pick up the wave characteristics of light, it doesn't pick up the photon characteristics* do they. See a photo-electric cell* picks up on the photon properties of light, but our eyes pick up on the wave properties of light.

S. Will I divide them.

T. If you want to. What you have is very good. What about this for an idea, why not put glasses and all the optical problems*, put them on one side--- the lens, the cornea and all that. You have to describe how they pick up on the (optical) problems--OK.
(Joint Construction (JC) for setting thematic pattern)

STUDENT EIGHT

S.ϕ I have got all this right, but just here I am starting to get into--- φ

T. What I suggest you might do, is to take them right up to the top and make them key things --- concepts--- you are going to relate everything to---an all this other stuff too. So let's just move these (concepts) up to the top---now this is just an idea.

S. Yea and the waves* come down from there? φ

T. Now what it seems to me is that you've got light and these are the characteristics of light---that they travel# in parallel rays*, there is reflection*, refraction*, and then the instruments---so that's your introduction.

S. Now comparisons between #--

T.---to compare and contrast# the differences for camera@ and---

S.---eye* and my other ones are telescopes*.

T. Oh you've got three, I thought you only had two to do.

S. Yeah---the camera and the human eye.

T. Then you can relate# everything within the use of these (instruments). That means your essay is on target and you are writing about the topic.

S. So these two are in the one paragraph and then two more where you go into more detail. φ

T. Definitely, I think this bit would be just your opening paragraph using these words "giving them the quality*" — that would be a fairly big paragraph, but your real topic is to compare the camera and the human eye and bring all these things in, on the way down, OK.

S. All right.

T. OK.
(Joint Construction (JC) for setting thematic pattern)

STUDENT NINE

S.ϕ How can you fit a number of words into one relational statement?

T. There are two ways--put it in "new relational statement" twice like this--with half at a time and then move them together like this.

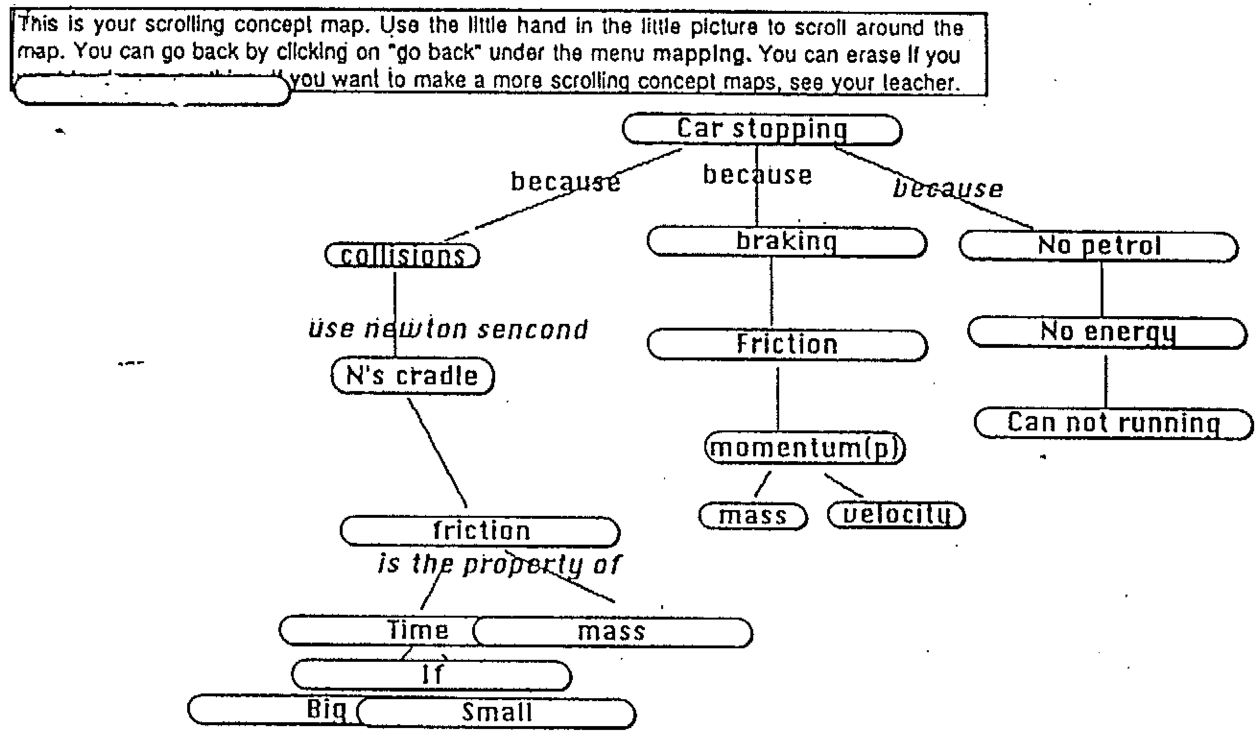
S. OK, so you can join lots of things. φ

T. Yes.
(Teacher question and answer (TQA) for setting the thematic pattern)

Appendix 7.5

An example of a concept map done by a student with poor language skills

This concept map indicates that cognitive processes for generating and structuring concepts have taken place even though the student's language skills are inadequate as can be seen from the corresponding essay.


This is your scrolling concept map. Use the little hand in the little picture to scroll around the map. You can go back by clicking on "go back" under the menu mapping. You can erase If you
you want to make a more scrolling concept maps, see your teacher.
Car stopping
because
because
because
collisions
braking
No petrol
use newton sencond
Friction
No energy
N's cradle
Can not running
momentum(p)
mass
velocity
friction
is the property of
Time
mass
If
Big
Small

SECOND ESSAY

Car Stopping

The cars stopping can braking.collisions.No Petrol.

First thing I am going to discussion Cars braking.The Cars run on the road when the traffic light turns to red clour the cars should stop before the Zebra Crossing.The cars usually can not stopping as soon as its braking,they may going one distance and then stop.Because running's cars has acceleration. When car braking the acceleration equal zero. So how far the car going after its breaking equal initial speed time "t".

The cars collisions can make car stop because Newton's second law show us:If an object exerts a force on another object (action) force, there is an equal force in the opposite direction from the second object onto the first (reaction force)for the same amount of time.So when the car hitsomething the thing will give the force to car in same car gave and opposite direction to car.This force exerts are important in time, if the time short the force became higher, if the time long the force becomes smaller.The another thing is when the car hitten something. There are have energy between the car and the things. Where are the energy after collisions? The energy may turn to noisy, damage the car or the thing.

This is not a sentence.
This is not a, will continue is d upon time "t".
You are going well

Incomplete. Only half 10

The essay will be marked according to the following criteria:

1. Is the genre clearly evident?	0 1 2
2. Is the language register consistent?	0 1 2
3. The use of paragraphs for one general concept?	0 1 2
4. The connectives used within paragraphs?	0 1 2
5. Correct spelling?	0 1 2
6. Legibility?	0 1 2
7. Sentence construction?	0 1 2
8. The range of concepts used?	0 1 2 3
9. The sequence of concepts used?	0 1 2 3
10. The scientifically correct concept linking?	0 1 2 3
11. The structural complexity of relationships used to arrive at a conclusion?	0 1 2 3
12. Present and/or future applications	0 1 2 3
13. Personal critical analysis?	0 1 2 3

$15 \times \frac{1}{2} = 7\frac{1}{2}$

Appendix 7.6
Comments in response to the text checkers

The comments indicate the usefulness of the spelling checker, grammar checker and documents statistics counter which were developed after the conclusion of the second extended study.

Teachers' Response to the Checkers

1. The spelling checker

(a) In what ways do you find this menuitem user friendly or not?

Students need to be made aware that the spell check will not check all words but only physics terminology.
Very easily located in pull-down menu.
In most "MAC Software" spelling, grammar, etc checks are located under menu item - TOOLS.

(b) Which students do you think it helps?

It would be of help to Vietnamese students. Infact many ESL students would find this useful. Infact ALL students would use this tool. It will encourage students to use longer words in writing physics essays.

(c) Do you think you can easily adapt it for your own needs?

Adding new words to the 'dictionary' is quite simple.
I would demand that use is made of the spell check for all students

2. The grammar checker

(a) In what ways do you find this menuitem user friendly or not?

Again, it is very user friendly. However there would be some students who would still not know which word to use, the existing or the one provided by the tool. For example "there" & "their" - there would be some ESL students that would be familiar with the differences. If a meaning could be provided, this would be very useful.

(b) Which students do you think it helps?

Again most ESL students would find this very useful.

(c) Do you think you can easily adapt it for your own needs?

Adding the to the field is a little more complex as it requires some knowledge of scripting. However, with careful steps provided for teachers, the task would be simpler.

3. The counter

(a) In what ways do you find this menuitem user friendly or not?

Very straight forward!

(b) Which students do you think it helps?

This will help all students as again it would encourage student to use longer words and write the correct amount for WBLA requirements.

(c) Do you think you can easily adapt it for your own needs?

Yes.

4. General comments.

Do you think the checkers complement the whole SLDP program? Would you suggest any other alterations or improvements?

Yes, the checkers do complement the SLDP program.
The "marker" is also of great use for students to have an of their progress while writing an essay.
The fact that the essay would be 'typed', would also be of are - easier to read.

Thank you for your assistance and time in trialling the program.
Pat

Appendix 7.7

Reference list for the contextual readings in the HCP modules

This reference list contains the references to the contextual readings used in the HCP modules. Permission to use these extracts was gained from the respective publishers where necessary. These permissions are contained in each of the HCP modules.

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