

## Designing teaching strategy to enhance student learning (II)

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*Abstract: This study investigates how the prior knowledge of the students can be used to develop an effective teaching and learning strategy. First- year university science students come from a variety of teaching and learning cultures with a wide range of academic abilities. Moreover many studies have shown that science students hold a variety of alternative conceptions that are hard to change. These combining factors pose a daunting challenge for the instructor to teach such a group of varying abilities and mixed conceptions. A traditional mode of teaching in many cases is not suitable and may result in a high drop out rate. Before embarking on a full teaching program, it is therefore, useful to develop a teaching and learning strategy that is suitable for the whole class. In this paper we will discuss the outcome of two years of study for two different groups of students.*

*Keywords: prior knowledge, learning culture, mixed conceptions*

### INTRODUCTION

This is the second part of the study conducted over two years with two different groups of students. The purpose of the research study was to investigate how the prior knowledge of students can be used to design an effective teaching strategy. (Part I of the study with 2001 group was presented at the 'Teaching and Learning Forum 2002'). For the sake of continuity and background reference, it is reproduced below along with the results for 2002 group.

The transition from school to university life for first-year students is not always smooth. This is partly because of a sudden change in the teaching and learning environment and partly because of exposure to new social environment. Developing familiarity with new teachers and colleagues takes a couple of weeks in semester one. This process may be full of thrills and joy for some students and stress and anxiety for other students. Learning new subject matter, time management, meeting deadlines for various assignments and preparing for on-course tests, all add up to an increased work load for first-year students. The situation becomes more stressful if the subject matter has not been well understood in lectures and tutorials, which often is the case. This further adds to students' frustrations and as a result many potentially capable students gradually drop out.

Students enter university with great expectations to pursue their career and would like to graduate with high quality attributes normally required by employers. In order to produce quality graduates and reduce attrition rate universities are continually encouraging and supporting practitioners to adopt quality teaching and learning practices. Therefore, generating an effective teaching and learning environment becomes the ultimate responsibility of the instructor.

## TEACHING METHODS AND STRATEGY

Our experience shows that there is not a single unique teaching and learning strategy that could effectively produce complete student satisfaction in the class. Teaching strategies depends on many factors, e.g., students' attitudes towards the subject, learning habits of individuals and year to year intake with wide ranges of student academic abilities associated with their background teaching and learning cultures (Zadnik & Yeo 2001) Some of these students come from schools that maintain very high teaching standards and practice conceptual learning, while the others come from schools where subjects may have been taught in a passive learning environment. Deep learning and reasoning is rarely practiced in such classes, as a result of which students develop their own model of fundamental concepts normally based on prior misconceptions.

Conceptual teaching and learning is a challenging task and varies from student to student. Its success depends on the knowledge and skills of the instructor and prior knowledge, attitudes and learning styles of the students. Moreover, science education research (White and Gunstone 1989) and (Hestenes, Wells and Swackhamer, 1992) shows that many students construct their own concepts that are termed as misconceptions by experts. Such misconceptions or alternative conceptions are hard to change with time.

The traditional mode of lecturing assumes that students already have the pre-requisite physical concepts and therefore, the instructor can proceed to deliver new content at a tertiary level. In general this method may be suitable for a small number of students in the class, but is not suitable for majority of the students whose conceptions are not adequate enough to understand the new content. This is evident in first-year science classes where students often stare at the board with a question mark on their face, expressing disbelief and dissatisfaction in the content being delivered. Therefore, this method is ineffective for many students, particularly in large classes where students are hesitant to ask questions because of fear or lack of confidence. As a result confusion and misconceptions continue to stay in their mind as it was before the lecture. Such teaching practices promote superficial learning inhibiting motivation and conceptual learning.

These combining factors pose a daunting challenge for the instructor as how to develop an optimum effective teaching learning strategy that is suitable for the entire class of varying abilities and mixed concepts. A carefully designed pre-test questionnaire may provide the instructor with some guidelines in designing his/her teaching strategy and eventually assess the effectiveness of such a technique and learning gains achieved by student (Thornton and Sokoloff, 1998).

## PRE-TEST QUESTIONNAIRE TO ASSESS STUDENT'S PRIOR KNOWLEDGE

We believe that to teach a unit effectively, the instructor should not assume that the students already have the pre-requisite knowledge of the unit content. In order to determine an optimum level at which to introduce the content, a pre-test questionnaire was designed for the first-year medical imaging science students to assess their prior knowledge about the subject. The pre-test questionnaire was based on the pre-requisite knowledge, Tertiary Entrance Examination syllabus and students' recent performance in the Tertiary Entrance Examination. The pre-test questionnaire (appended) had 16 questions for 2001 group and 20 questions for 2002 group quizzing various components of the unit content.

The pre-test was conducted during the very first lecture in the class. No time limit was imposed to complete the questionnaire so that student could think carefully before answering the questions.

The analyses of the pre-test exposed the weaknesses and strengths of the class. From this information an optimum level for the content delivery was determined, which formed the basis on which subsequent teaching material was constructed. During the semester weaker concepts were often repeated in the lectures at the expense of the stronger concepts.

After five weeks of teaching, the pre-test was re-administered for 2001 group and after twelve weeks for 2002 group. From here on we will call it post-test. Generally students try to memorize difficult concepts when preparing to sit a test. Therefore, the test was conducted with out advance warning to exclude rote learning assessment. The student performance on the post-test was then compared with the on-course test and the end of semester final exam to draw any conclusions.

The questions in the on-course test and the final exams were different from those in the pre and post-tests, but most of these were based on the conceptual knowledge acquired in the post-test.

## RESULTS AND DISCUSSION

The data of the pre- and post-test for 2001 and 2002 group are shown in Fig.1. and Fig. 2. respectively. These graphs show the number of students who correctly answered the questions in the pre-and post-tests versus the question number. Both groups show a similar trend in their performance indicating significant improvement in conceptual learning and retention of key concepts.

These graphs also show that post-test responses to question 4, 5, 9 and 11 for 2001 group and question 5, 7, 12 and 19 for 2002 group were still not satisfactory. Contrary to our previous interpretation, we now believe that student could not answer some of these questions because they either required formulas which of course students were not expected to remember or were dependent on memorization. (Formula sheet is provided only in the On-Course Test and the Final Examination)

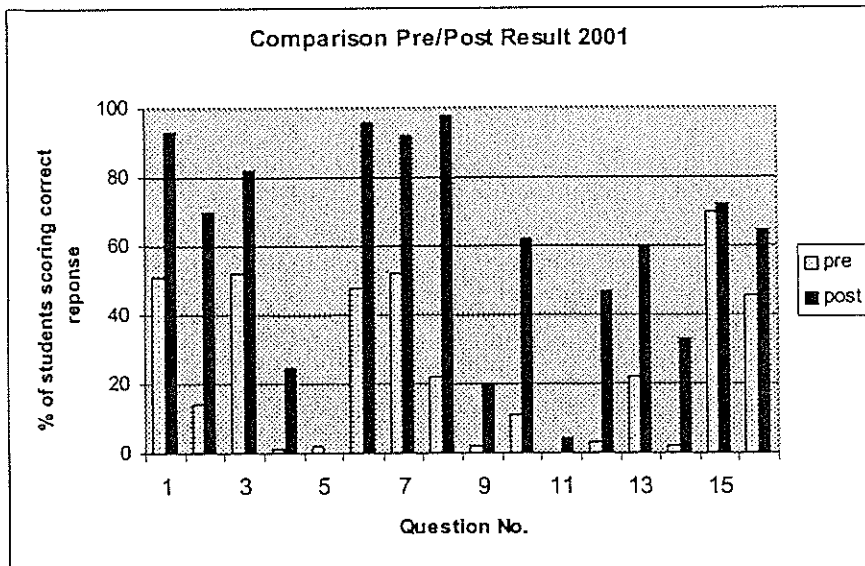


Fig. 1. Pre and post-test results for 2001 group (light and dark bars respectively), comparing % of students scoring a correct response on each question in the pre and post test. The graph shows significant improvement in student learning for most of the questions.

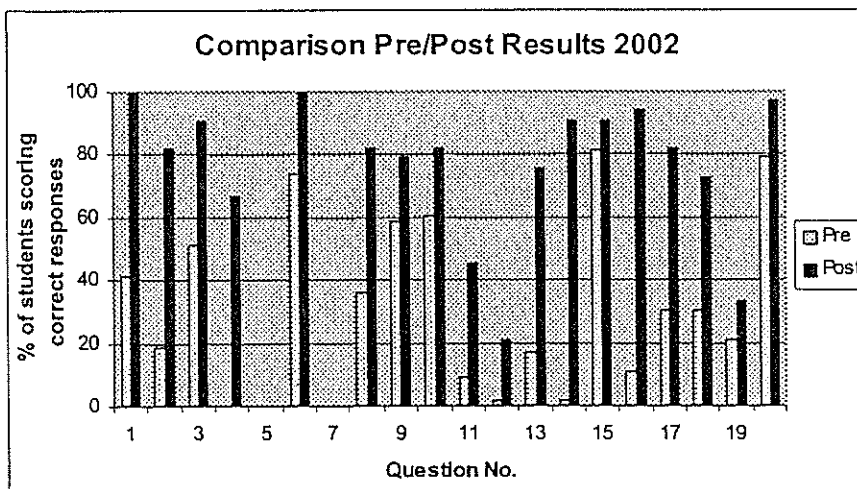


Fig. 2. Pre and post-test results for 2002 group (light and dark bars respectively), comparing % of students scoring a correct response on each question in the pre and post test. This graph shows significant improvement in student learning for most of the questions.

Comparison of pre and post-test scores for 2001 group and 2002 group are shown in Fig. 3. and Fig. 4., respectively. Both groups of students are showing similar trend. The large shift in the mean score of the post-test distribution for both groups indicate that the new teaching method has significantly improved student learning.

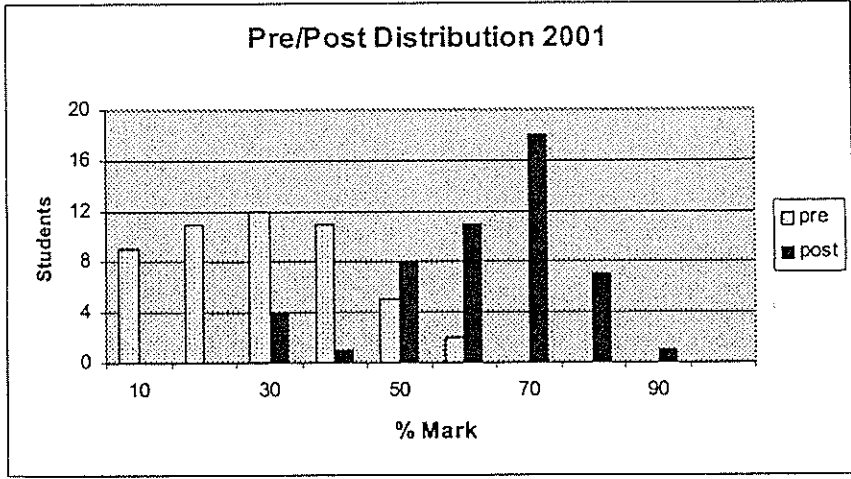


Fig. 3. Distribution of pre and post-test marks for 2001 group (light and dark bars respectively). The large horizontal shift in the distribution of marks shows the improvement in student learning.

Mean pre-test=24.9 ± 12.9, Mean post-test=57.4 ± 14.0

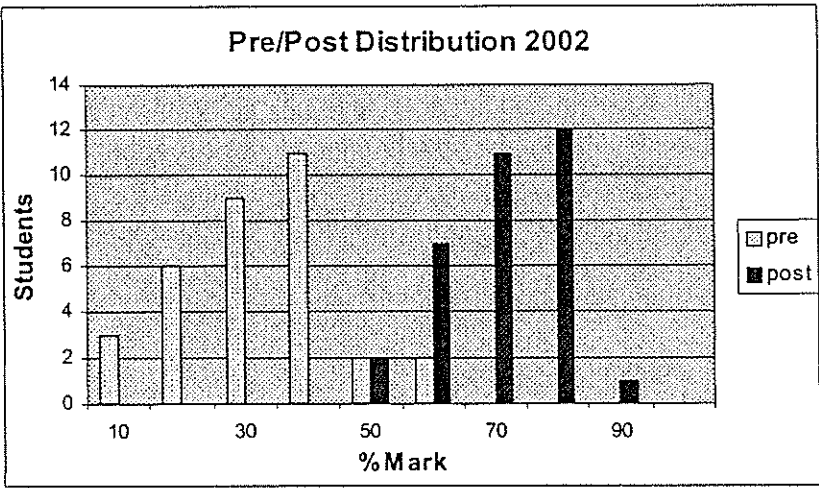


Fig. 4. Distribution of pre and post-test marks for 2002 group (light and dark bars respectively). The large horizontal shift in the distribution of marks shows the improvement in student learning.

Mean pre-test=30.5 ± 12.2, Mean post-test=69.2 ± 9.1

The pass rate and average mark for the 2001 group and 2002 group are tabulated in Table I. Since no systematic study of this kind was conducted in 2000, therefore, it is not possible to compare these two groups with 2000 group.

In general the data shows improvement in student performance in post-test and on-course test. The performance of 2002 group is better than the 2001 group as reflected in pre-test pass rate of 9% compared with 6% for 2001 group. It appears that this may be partly due to a better intake of students in 2002.

Comparison of final exam results for three groups is shown in Table II. The figures indicate a 10 % improvement in the average mark and 5.7% improvement in the pass rate over 2000 group, where as the results for the 2001 and 2002 groups are consistent. We believe that this strategy is effective as reflected by the consistent performance of 2001 and 2002 groups.

Table I. Pass rate and (average mark, x) scored in pre-, post-, on –course test for 2001 group and 2002 group

Year	Pre-test	Post-test	On-Course Test
2001	6% (x =25%)	76% (x = 57%)	90% (x = 70%)
2002	9% (x =30%)	100% (x = 69%)	100% (x = 81%)

Table II. Comparison with previous years final examination results

Year	No. of students	Average mark	Pass rate
2000	69	59%	88%
2001	58	65%	93%
2002	53	65%	92%

## CONCLUSIONS

This study conducted over two years for two different groups shows that a two-part strategy consisting of assessing the prior knowledge of students and then developing teaching methods to address the weaknesses of the class, has significantly improved student learning as reflected in various assessments.

The post-test with out prior warning has excluded rote learning assessment and therefore, provides a measure of students learning and concept retention. A 10 % improvement in the average mark and 5.7% improvement in the pass rate over 2000 group and a consistent performance by 2001 group and 2002 group indicate effectiveness of the teaching strategy.

This study also shows that student's performance further improves when they are provided with a formula sheet in exams. Such support material gives them a certain degree of confidence in exams, as they do not have to rely on memorization, where inadvertent error in formula or calculations are likely to happen in a tense examination environment.

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**APPENDIX A**  
**PRE/POST-TEST QUESTIONNAIRE 2001 GROUP**

Curtin University of Technology  
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Department of Applied Physics

This questionnaire is intended to get some feedback from students. It is not intended for grading.

Please feel comfortable and briefly answer the following questions.

=====

=====

1. What are the two basic components of an x-ray tube?

(a) ..... (b)  
.....

2. How are x-ray produced?

3. Is the x-ray spectrum polyenergetic or monenergetic?

The following statement refers to Q4, 5, 6, 7 and 8.

Assume  $I_1$  is the intensity of the x-ray beam when the tube is operated at 100 kVp, and  $I_2$  is the intensity of the beam when the tube is operated at 50 kVp. (kVp means peak kilo volt)

4. (a) Sketch the shape of the x-ray spectrum at 100 kVp, (plot Intensity vs Energy)  
(b) Explain why it has this shape.

(a) ..... (b)

5. What is the intensity ratio of the two beams?



6. Which beam is more penetrating, 100 kVp or 50 kVp?

7. Which beam will produce more darkness (radiographic density) on film, 100 kVp or 50 kVp?

8. If radiograph of a knee phantom is taken, which beam will produce higher contrast 100 kVp or 50 kVp?

9. What is the basic principle of radiography?

Normally an x-ray beam is described by two terms, called Quality and Quantity .

10. (a) What is quality of an x-ray beam? (b) What is quantity of an x-ray beam?

(a)	(b)
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11. If an x-ray tube is operating at peak voltage of 100 kV, what is the maximum energy of x-ray photon?

12. State 4 properties of x-rays

1. ....

2. ....

3. ....  
 4. ....

13. Name at least two medical imaging modalities where x-rays are used.

1. .... 2. ....  
 .....

14. Why filters are used in x-ray tubes?

.....

15. After an x-ray exposure the patient becomes radioactive? Yes / No

16. You will be wearing radiation badge when working in the x-ray labs. (a) Is wearing radiation badge mandatory? (b) What does this badge measure? (c) And what are the units.

(a) .....  
 (b) .....  
 © .....

Thank you for your time.

**APPENDIX B**  
**PRE/POST-TEST QUESTIONNAIRE 2002 GROUP**

Curtin University of Technology  
School of Applied Science  
Department of Applied Physics

This questionnaire is intended to get feed back from students. The result of this questionnaire will not be included in assessment. Please feel comfortable and answer the following questions.

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Name ..... Unit: ..... Gender: Male / Female

4. What are the two basic components of an x-ray tube?

(i) ..... (ii) .....

5. Describe how x-rays are produced.

6. Is the x-ray spectrum produced by an x-ray tube polyenergetic or monenergetic?

The following statement refers to Q 4, 5, 6, 7 and 8.

Assume  $I_1$  is the intensity of the x-ray beam when the tube is operating at 100 kVp, and  $I_2$  is the intensity of the beam when the tube is operating at 50 kVp. (kVp means peak kilo volt applied across the x-ray tube)

6. Sketch the shape of the x-ray spectrum at 100 kVp, (Plot Intensity vs Energy)

7. What is the intensity ratio of the two beams?

$$\frac{I_1}{I_2} =$$

10. Which beam is more penetrating, 100 kVp or 50 kVp beam?

11. The intensity of x-ray beam produces darkness on film. This is called radiographic density or density D. What is the density ratio produced by the two beams?

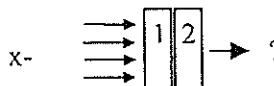
$$\frac{D_1}{D_2} =$$

12. We are able to see radiographic image because there is density difference between various regions on the film. The difference in density is called the contrast. If radiograph of a knee is taken, which beam will produce higher contrast image, 100 kVp or 50 kVp beam?

13. Explain how image of a hand is formed when x-ray pass through the hand. That is what physical interaction takes place within the hand to form the image.

14. Suppose a 5 mm thick sheet of lead cuts down the intensity of x-ray beam by 50%. If another identical sheet is added to the first one then the combined thickness will cut down the intensity by:

- a. 25%
- b. 50%
- c. 75%
- d. 100%
- e. none of these



15. If an x-ray tube is operating at peak voltage of 100 kV, what is the maximum energy (in eV) of an x-ray photon produced?

16. State at least 4 properties of x-rays.

1. ....

2. ....

3. ....

4. ....

17. Name at least two medical imaging modalities where x-rays are used.

1. ....

2. ....

14. Why filters are used in x-ray tubes?

15. After exposure to x-rays does the patient becomes radioactive? Yes / No

16. X-ray film is often loaded in intensifying screen cassette when taking radiograph of a patient.

What is the purpose of using intensifying screens in diagnostic radiography?

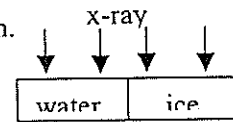
17. An x-ray film is equally sensitive to x-rays and light (a) True (b) False

18. While studying at night you may have noticed that when you place your hand under the table lamp, the shadow of hand formed on the desktop is fuzzy around the boundaries. If the table lamp is now replaced by an x-ray tube. Would the image of hand formed on x-ray film be fuzzy? (a) Yes (b) No

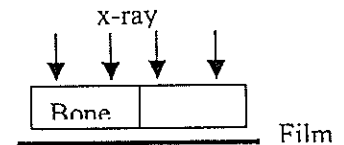
19. When x-ray traverses through any material its intensity is reduced.

Consider an x-ray beam traversing through equal thickness of ice and water. In which material x-ray intensity will be reduced more? Explain.

(a) water                      (b) ice  
Explanation:



20. Consider an x-ray beam traversing through equal thickness of bone and muscle.  
Explain why the image of bone on film appears whiter than muscle?



Thank you for your time.