teachingscience

Teaching Science is a quarterly journal published by the Australian Science Teachers Association. This journal aims to promote the teaching of science in all Australian schools, with a focus on classroom practice. It acts as a means of communication between teachers, consultants and other science educators across Australia. Opinions expressed in this publication are those of the various authors and do not necessarily represent those of the Australian Science Teachers Association or the editorial advisory committee.

Contributions to Teaching Science are peer reviewed.

Australian Science Teachers Association

PUBLISHED BY:
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COVER PHOTO: Australian Stem Cell Centre
DESIGN/LAYOUT: Josie West
PRINTING: Bluestar Print Group

ISSN 1449-6313
Contents indexed in Australian Education Index (ACER) and Current Index to Journals in Education (ERIC).

Contents

Do-It-Yourself Astronomy: Getting the best out of a science kit

By Léonie Rennie, Christine Howitt, Rosemary Evans and Fiona Mayne

This paper reports an investigation of how four teachers in four different schools used an Astronomy Science Kit. Their varied experiences, along with their varied levels of knowledge and experience in teaching science, considered in the context of other research about science kits, are used to draw conclusions about how best such Do-It-Yourself Science Kits might be prepared and used by teachers in their classrooms.

Introduction

Do-It-Yourself (DIY) Science Kits provide sets of science equipment, including worksheets and/or teachers' guides, and are valuable science resources for poorly equipped schools, particularly those located in geographically isolated areas. Our local science centre, Scitech, has prepared a number of DIY Science Kits, suitable for Years 4 to 7, available for loan to any Western Australian schools. The website (http://www.scitech.org.au/do-it-yourself-science) describes the kits as containing:

> *all the equipment and resources required to conduct a series of themed lessons, experiments and investigations around a particular topic. Each kit comes with the required materials, complete experimental instructions, reproducible resources, background theory outlines and more!*

In this research we investigated the use of a new DIY Kit prepared by the science centre that focused on astronomy. This Kit is particularly topical in the context of preparation for the Square Kilometre Array (http://www.ska.gov.au), which is hoped to be located in Western Australia. More broadly, science kits are important in the context of the *National Curriculum: Science*, because they provide additional opportunities to involve students in hands-on activities and inquiry-oriented science investigations.

The Use of Science Kits in Schools

Science kits are commonly used, particularly in primary schools, as a means of promoting science teaching and learning. Some programs implementing new curricula, or districts endeavouring to improve science achievement, have trained teachers in the use of provided kits. Surveys of teachers in such programs have shown that they believed using the kits increased their science knowledge, attitude to science and science teaching skills (Rubino, Barley, & Jenness, 1994), and also that kits improved their students' attitudes to science and also science learning (Rubino, Barley, Jenness, Pearl, & Bonda, 1994). Further, students of teachers using science kits achieved higher Science scores than students in non-kit classes (Young & Lee, 2005). A five year study of teachers implementing a kit-based curriculum with intensive professional development, determined that teachers became more confident about their ability to teach science (Fetters, Czerniak, Fish, & Shawberry, 2002). A study by Sherman and MacDonald (2008) demonstrated that rural teachers who were given professional development in using science kits found that:

> *the benefits include increased teacher content knowledge, pedagogic content knowledge, teacher confidence, and enthusiasm for science* (p. 97).

However, in all of these studies, teachers had been trained to use the kits. Other researchers have shown that teachers believed that hands-on kits would help them to be effective teachers (Lumpe, Haney, & Czerniak, 2000), although this belief was not tested. Harlen and Holroyd (1997) found that teachers with low confidence and understanding about science teaching placed heavy reliance on kits and prescriptive work cards, suggesting that they may not increase their own learning (Olguin, 1995). On a more positive note, case studies of two teachers who had previously tested science kits found that once they overcame initial concerns with organising both the new science kit materials and their classes, and became more experienced, they became more confident in their use, and indeed used the kits in different ways to that suggested (Jones & Eick, 2006). Given this, the question arises, how effective are DIY Science Kits if teachers have no training in their use?

Science kits are a common form of outreach and they are usually offered for loan without requiring teachers to be trained in their use. For example, the Australian Museum advertises more than twenty-five kits, nearly all science-based, available for loan in their Museum-in-a-Box program (http://australianmuseum.net.au/Museum-in-a-Box). It is difficult to find any evaluative reports on their effectiveness, or information about how teachers actually use them. Most evaluation takes the form of feedback sheets completed by the teachers who borrow the kits, but we have not found any syntheses of these to inform our understanding of their effectiveness or how best to use them. Our earlier explorations of the effectiveness of DIY Kits, reported to *Scitech* staff, suggested that they do provide useful resources for hands-on investigations, especially in schools that are poorly resourced, but their effectiveness depends on the skills of the teacher. We found that teachers with good pedagogical knowledge but who lack confidence in their own science knowledge, can use the kit effectively but student learning tends to be limited. Although the kits may assist teachers to develop science knowledge, teachers need good pedagogical content knowledge to be able to link science concepts to out-of-school, everyday situations and thus promote students' understanding of science in out-of-school contexts.

Scitech staff developing a new kit focused on astronomy, made use of our earlier research and endeavoured to provide adequate background knowledge of the concepts illustrated in the kit, including in the teachers' materials, the students' booklet and activity sheets. However, there was no requirement for teachers to be trained in use of the kit. In this research we investigated use of the new Astronomy DIY Science Kit, aiming to answer four questions that would enable us to provide guidance about effective use of the Kit. The questions are: How did teachers make use of the Astronomy Kit? How did students respond to the Kit? What were teachers' opinions about the Kit? How can the Kit best be used to promote science learning in schools?

Description of the DIY Astronomy Kit

The DIY Astronomy Science Kit includes a wide range of activities, materials, and equipment to allow students to investigate topics about the Earth, the Solar System, the Universe, stars and meteorites. It is available to Western Australian schools on loan for eight weeks, or about one school term. It comprises fifty-four different kinds of items packed into three large containers (more easily carried by two people than one person!). There is sufficient equipment for a class of thirty-two, working in pairs. Many items are consumable (for example, alka-seltzer tablets, astronaut ice cream, balloons, straws, pins, fishing line) but the Kit also contains some expensive equipment, with total replacement cost in excess of $4000. The more expensive items are a set of 8 genuine meteorites ($300), a wooden-framed Sunspot Viewer ($550), and a *SkyScout* ($650), which contains a GPS device and is programmed to find any celestial object at any time of the day or night. There is also a *Teacher's Guide*, a *Give Me More* booklet of further information and activities for students, sixty-seven laminated Activity Sheets, and a *SkyScout* Manual. A CD-ROM disk is provided with the Kit containing pdf files of all of the written contents and can be retained by the teacher for future use as a resource.

Research Design

The research was conducted in three stages over two school terms and investigated the use of the DIY Astronomy Kit in four Western Australian schools and in a workshop for different teachers. In Stage One, data was collected in three schools by semi-structured interviews with the teachers after they had used the Kit, having voluntarily booked its loan. The researchers had examined the Kit and its materials prior to beginning

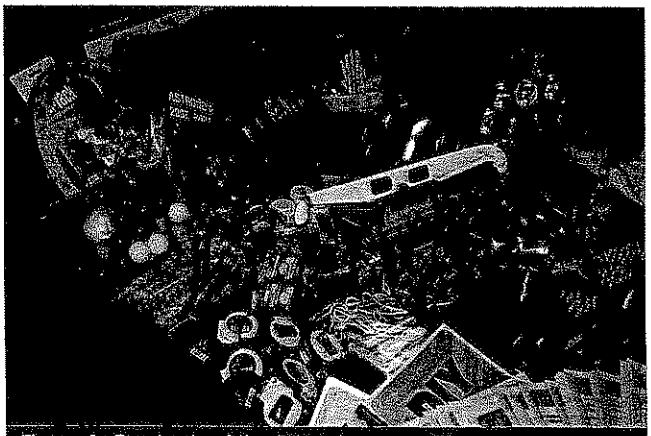

Figure 1: Contents of the DIY Astronomy Kit.

the research so that appropriate questions could be framed, and then allowed the interview to develop according to teachers' responses. The main questions related to how the kit was used, how the students responded to it, and the teachers' opinions about the effectiveness of the kit. In these schools, the Kit was used by a Year 8 class, a Year 6/7 class, and a Year 5/6 class. Interviews with Stage One teachers were transcribed and the transcripts provided to teachers for checking. The main research questions were used as an initial framework for analysis and themes were identified by repeated reading and discussion among the researchers.

In Stage Two, based on the findings from Stage One, two of the researchers worked with a teacher in a fourth school in the context of an after-school Astronomy Club for Years 4 to 6 students. Three researchers, who were all experienced science teachers, were able to contribute both content and pedagogical content knowledge to the development of a sequenced and coherent program using activities presented in the Kit. Data was collected over a five week period by one or two of the researchers formally observing students and the teacher using the Kit. In each session, one researcher and a volunteer parent assisted supervising groups of students as they worked on activities. Extensive field notes were made by the researchers who observed each session and reflective post-session discussions among the teacher and the three researchers assisted in identifying themes as well as leading into the planning of subsequent sessions.

In an informal Stage Three of the study, three of the researchers offered a two hour workshop on the Kit at a science teachers' conference. The purpose was to obtain the considered views of experienced science teachers and to determine whether or not their perspectives were in line with, or differed from, those of the teachers who had been part of Stages One and Two. Twelve high school science teachers were introduced to the Kit, interacted with and discussed the materials, especially the Sunspot Viewer and the *SkyScout*. Conversations with these teachers, both individually and in a group discussion, enabled the researchers to obtain their opinions about the Kit.

Data from the informal Stage Three was discussed amongst the researchers and used to extend the findings relating to teachers' opinions about the Kit.

Findings: Teachers' Use of the Astronomy Kit and Students' Responses

Stage One: Interviews with Teachers from Three Schools

The three teachers, Guy, Peta, and Remmy (all pseudonyms) implemented the Kit in different ways.

Guy's experience

Guy, an experienced Year 8 science teacher, used the Kit over a period of five weeks as part of his scheduled four, sixty minute lessons per week. This included an astronomy night at a school camp, but the weather was overcast and limited the use of the *SkyScout*. During another evening session at the school, a visiting astronomer set up three of his telescopes for students to view the night sky, but only adults were allowed to use the *SkyScout*. Guy did not inform his students of the Kit's presence at the school, so they were unaware that some resources they used were on loan.

Guy considered some suggested activities had not been thought through in a practical sense. For example, using toilet paper to demonstrate distance in the Solar

System turned out to be ineffective on a windy day. He stated that his students enjoyed the activities and they were particularly impressed with the meteorites. Even though they were small (less than 20 grams), many students had not previously seen a genuine nickel-iron meteorite and were amazed by their age.

Guy reported being overwhelmed by the quantity of material in the Kit (some of which he found inadequately labelled), and he felt confused by the overlap between the *Teachers' Guide*, *Give Me More* Booklet for students and Activity Sheets. Guy decided to mostly use the school's own equipment, which was easily available in his well-equipped high school. This avoided risk and unnecessary use of Kit materials for which there was a replacement cost if consumed or damaged.

Peta's experience

Peta, who taught a split Year 6/7 class, spent some time during her vacation viewing the CD-ROM and deciding what activities would best suit her class during Term 1. She confessed that, although she was an experienced primary teacher, she did not feel confident about Science. She was able to obtain the Kit prior to the beginning of term and examined it carefully. This took a great deal of time because of the quantity of material it contained. She was able to ask her husband to assist with using equipment that was unfamiliar to her. Peta chose several activities she thought the class would enjoy and that fitted her planned curriculum, and then selected only the equipment she would use, putting the rest aside. She considered the Kit to be very complete and no additional resources were necessary. The flexibility offered by the Kit allowed her 'to go with the students' interests'.

In the first of her ten, ninety minute lessons, Peta introduced the Kit to students and modelled one activity which the class then completed in groups. In subsequent lessons, a different group of students selected an activity from those Peta had chosen, practised it (with Peta's help if necessary), and then led the other groups in the class to complete the activity. This enabled students to practise their science communication skills. Peta also incorporated other aspects of astronomy in her Technology, English and Mathematics lessons, thus allowing cross-linking of the ideas and concepts about astronomy. Peta reported that, 'The students' eyes were opened to a new field of science', and doing the activities helped them *feel like real scientists* and develop a deeper understanding of the concepts demonstrated.

Remmy's experience

Remmy had been teaching in primary schools for four years and considered herself to be a science specialist. Her split Year 5/6 class used the Kit for eight weeks and she saw it as an opportunity for her to access equipment not normally available in her rural school. Although impressed with the extent of the Kit, she considered it had too much information and equipment for the short time she had it. Remmy thought there were good connections between the booklets and activity sheets and found the written material provided useful background information.

Remmy did not follow a set program and did not use the Activity Sheets. Instead, she took an idea or activity and modified it to suit her class. She also tried new activities. For example, the class did not know what a Sunspot Viewer was, so she took it outside and she and the students explored it together. However, she did not allow use of the *SkyScout*. She was pleased to keep the CD-ROM and had filed it among her own resources. Remmy reported her students 'loved the Kit', and were very disappointed when the Kit had to be returned because there was still so much of it they had not used. She felt they were gaining greater understanding of concepts through direct exploration.

Stage Two: Five Sessions in the Astronomy Club

Fiona was a first year teacher with little science background. She used the Kit in an after-school Astronomy Club over five weeks for twenty-four Year 4, 5 and 6 students who volunteered to participate in the Club. Fiona coordinated the Club and worked closely with two of the researchers to establish the content and sequence of activities for a ninety minute session on a Monday after school.

Initially, Fiona found the information and contents of the Kit overwhelming, making it difficult to find a starting point, particularly in the absence of a fixed curriculum. Clearly a theme was needed, so the fictional character of "Kosmo" was created. This space travelling alien allowed both a context and a storyline to be developed to provide a focus for the Club's activities. This enabled Fiona and the researchers to choose freely among the written materials and the equipment to implement activities that would engage the students and contribute to the theme. Additional resources, such as clothing to simulate space suits, were occasionally included. The expensive Sunspot Viewer and *SkyScout* were taken home for safe-keeping.

Each week, a Kosmo story introduced students to the structure of the session then, in three groups of eight students, they rotated around three activities supervised by Fiona, one researcher, and a parent helper. Students were asked questions to stimulate thinking about a specific problem that was investigated through a hands-on activity. Each session finished with a whole group discussion of the activities and the related science concepts. The final week of the Astronomy Club was a celebratory event and parents were invited to attend. Groups of students took charge of some of the activities used in the previous four weeks, and explained these to their parents. The science centre provided a space dome and demonstrator to enable parents and students to observe the night sky. Poor weather prevented use of a telescope or the *SkyScout* during the session. This evening was enjoyed by students and parents, and enabled the researchers to converse informally with parents about their children's participation in the Club.

Students engaged productively with all the activities, whether they were from the Kit or not. They appeared eager to learn, were engaged throughout the full session and asked many questions during the end

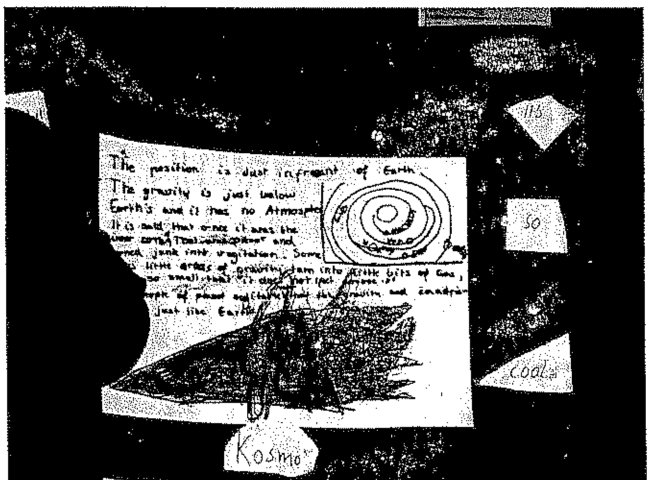

Figure 2: Poster of Planet Vegitable, where Kosmo is a carrot.

discussion. They enjoyed sharing their new astronomy knowledge with their families in the final session of the Club, and parents spoke of their child's excitement during the activities.

Stage Three: Workshop for Teachers

The teachers involved in the first two stages of the research used the Kit with students in Years 4 to 8. However, all of them considered some equipment to be too expensive or sophisticated for use by students of this age. Further, because there was only one *Skyscout*, for example, only one person at a time could use it. The researchers offered a workshop at a science education conference aimed at teachers so that a wider perspective of teachers' views might be obtained. Most of the twelve teachers who chose to attend were high school science teachers and they were very interested in the Kit's contents, particularly the unique aspects, such as the real meteorites, the Sunspot Viewer and the *SkyScout*. While many teachers considered a number of the suggested activities to be trivial and not suitable for high school classes, they believed the unique components to be valuable assets to teachers of senior high school science and also physics. They suggested that such items might be available as 'mini-kits' for short term hire, which would be much more convenient to handle than the three cases full of equipment for the whole Kit.

Conclusions: Teachers' Perceptions of the Kit

All teachers who used the Kit were impressed with its thoroughness, diversity and depth, and they acknowledged that the Kit offered a fresh approach to teaching astronomy. They also believed that their students appreciated the Kit and obtained valuable learning experiences from its use. However, the Kit was far too comprehensive to be used in the time available. Further, the quantity of material was confusing to sort through and frustrating to try to keep organized. The teachers responded by more or less giving up (Guy), spending time preparing a program and removing much of the equipment (Peta), just trying out bits according to interest (Remmy), or accepting the help of more experienced teachers to select appropriate equipment to develop a program (Fiona and the researchers). Fiona borrowed the DIY Astronomy Kit again the following year, and although she found the large volume of materials confusing, she now had sufficient confidence to choose appropriate activities for her class.

Remmy found the worksheets bland and most of the activities difficult for her Year 5/6 students. Peta and Guy were happy with the conceptual level, but found it very time-consuming to sort through the Kit before use to find out what it contained. They also mentioned the problem of daylight-saving time which made it very late for night-time viewings of the stars and planets. Neither Remmy nor Peta included a night activity, and Guy reported his Year 8 students were very tired the day after his astronomy evening.

Apart from Remmy's use of the Sunspot Viewer and some adults' use of the *SkyScout* at Guy's astronomy evening, teachers did not allow students to use expensive items in case they were damaged (as they could not afford to replace them), thus defeating the purpose of having such expensive items in the Kit. In contrast, the high school science teachers at the workshop regarded these items as the most valuable part of the Kit, because they were not available at their generally well-equipped schools. As these teachers had considerable astronomy content knowledge and would be using the Kit with older students, many of the other activities were regarded as too simple for their students, and so the value of the Kit to them depended on the expensive items.

Overall, teachers regarded the Kit as a valuable hands-on resource, particularly for rural and remote schools, where children rarely 'had the opportunity to see such things'. They thought the Kit promoted interest in Science. Some suggested that the provision of student and teacher 'reflection sheets' would be useful to aid learning.

Best Use of the Kit

Fulfilling the potential of the DIY Kits to promote teaching and learning of Science depends on making effective use of them in the classroom. This research, in the context of our earlier findings about DIY Kits, has contributed to the following conclusions.

Kits must be carefully targeted at their users

- A DIY Kit must be well organized, with clear labelling and storage places for its contents. The amount of material provided needs careful consideration and should match the length of the loan period.
- Kits should be designed for particular Year levels with activities/worksheets of appropriate difficulty and challenge. Supporting science information must be readily accessible by teachers and matched to their likely science content knowledge.
- A photographic guide to components, and how activities look when set up would assist teachers who lack confidence and experience.
- Expensive, sophisticated items should be supplied as mini-kits for teachers who are aware of what they are borrowing and how it can best be used in their classroom context.

The effectiveness of Kits depends on teachers' knowledge

- To promote science learning, teachers must be willing, and have the opportunity, to familiarize themselves with the contents of the Kit **before** the loan period. The CD-ROM of its contents, provided when the Kit is booked, facilitates preparation, but only if teachers are prepared to read the CD-ROM.
- The range of items within the Kit allows flexibility in use. Teachers with good pedagogical content knowledge can plan a sequence of lessons around the Kit and also integrate the science with other subject areas and with science outside of school.
- Teachers with less science content knowledge can be more selective about what to use from the Kit. These teachers can learn with the Kit, even while their students are learning. Such an approach allows teachers to develop their pedagogical content knowledge while using the Kit.
- Although students invariably enjoy doing the science activities and using the Kit's resources, they are more likely to acquire lasting knowledge when teachers are able to link the various activities to provide context and meaning to the science concepts. Teachers require sound pedagogical content knowledge in order to structure such a sequence of lessons.
- DIY Kits are likely to be most effective when teachers have had some professional development in their use. Not only would this give teachers (who are invariably time-poor) an opportunity to become familiar with the possibilities of Kit use, it could promote pedagogical content knowledge.

Acknowledgements

This research was carried out under an Australian Research Council Linkage Grant (LP0455587) to Léonie Rennie at Curtin University, in partnership with Scitech and Rio Tinto Future Fund in connection with the Kids' Science State Initiative. The opinions expressed in the article are those of the researchers and should not be attributed to the funding body. Grateful thanks are extended to Scitech staff, the teachers and students who participated in the research. Information about the hire of the DIY Science Kits is available from Scitech at http://www.scitech.org.au/do-it-yourself-science

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