Using Enrichment and Extracurricular Activities to Influence Secondary Students' Interest and Participation in Science

Peter Eastwell
Science Time Educational Consultancy, Queensland, Australia
willdown@gil.com.au

Léonie Rennie
Curtin University of Technology, Western Australia
irenniel@info.curtin.edu.au

Abstract

A quasi-longitudinal case study was used to determine the effects on secondary students of participation in a program of enrichment and extracurricular science activities in terms of their interest and enjoyment in being involved in science activities, their motivation to continue to participate in science, and their perceptions about scientists and about the role of science in society. Two groups of students in an Australian school were followed simultaneously, a junior cohort through Years 8 to 10 and a senior cohort through Years 10 to 12. Data were collected from 20 students; 5 girls and 5 boys from each cohort. A strong positive relationship was found between changes in students' interest and enjoyment and changes in their motivation, and both these variables increased, in an overall sense for the combined student population, during the study period. All students generally held a high perception of both the normality of scientists and the importance of science in society throughout the study period. Participation in science activities impacted overall positively, but to varying extents for different activities, on all four dependent variables. Suggestions for the structure and/or conduct of competitions, excursions, and practical work, including the design of museum exhibits, and implications for further research are presented. The paper is based on the first author's doctoral dissertation.

Introduction

Many schools offer a range of enrichment and extracurricular science learning experiences to their students, such as participation in competitions, excursions, guest evenings, practical investigations, work experience, vacation schools, and seminars. Primary aims of providing these are to motivate students to continue their participation in science and to promote an understanding of the importance of science. At the same time, many of the activities provide practice in some of the processes of science. But how effective are these enrichment and extracurricular activities? Are their outcomes worth the time and teacher effort required to organise them? Given that the Australian climate is characterised by the need for more graduates with a background in science and technology and a generally negative perception of the population of science and scientists (Eastwell, 1998), do these activities have a positive effect on students' attitudes and perceptions about science?

This study is based on data from 20 students. The choice of this relatively small population was necessary to ensure, in the context of available resources, a feasible detailed longitudinal study. The dependent variables measured in the study are not necessarily variables that change dramatically, and the influences of experiences such as enrichment and extracurricular science activities can be long-term. While other studies might answer different questions effectively using cross-sectional designs, the longitudinal design appears most appropriate in attempting to answer the research questions persuasively, because time is allowed for both short- term and longer-term effects to be realised.

Research Question

This article reports the findings of a study designed to answer this four-part question: What effects does students' participation in enrichment and extracurricular activities have on their interest and enjoyment in being involved in science activities, their motivation to continue to participate in science, and their perceptions about scientists and about the role of science in society?

Method

The study was carried out at Glendale College (a pseudonym), a relatively small independent, coeducational, primary and secondary, day and boarding school situated in a small rural Australian city in the state of Queensland and having a predominantly Caucasian population. The majority (70-85%) of secondary students at each year level were boarders who came from diverse locations which included rural Queensland and Northern New South Wales, metropolitan areas, and, to a lesser extent, Asian countries. The academic abilities of secondary students covered a broad range.

During their senior years, students could choose to study any one or more of the subjects Biology, Chemistry, and Physics, and enrolments in these subjects, including male-to-female ratios, were broadly typical of data for Queensland as a whole (Beasley, Butler, & Satterthwait, 1993). Science classes at the college were taught by four experienced Caucasian teachers (two male and two female), two of whom originated from overseas and had overseas teaching experience. The first author was the researcher and one of the male teachers, also serving as Head of Science. As such, he taught most of the students selected to be involved in the study.

The quasi-longitudinal research design adopted involved following simultaneously two cohorts of students through 2.5 years of secondary education; the first (junior) cohort from the middle of their Year 8 to the end of Year 10, and the second (the senior cohort) from the middle of Year 10 to the end of Year 12. Data were collected from a sample of students within each cohort. As a result of attrition, the composition of the two student samples varied during the study period. However, information was collected in such a way that the final analysis of data involved 10 students (five girls and five boys) from each cohort; 20 students in all. The final junior sample students were a generally able group (8 of these 10 students achieved at an A or B level, of six possible levels A-F, in their Junior Science course), and at least 8 of the 10 final senior sample students proceeded to a tertiary science, or science-based, course. The tertiary destination of one student is unknown.

Data were collected primarily by three annual interviews during 1992, 1993, and 1994, interviews that varied in length from approximately 20 minutes to 55 minutes. During the interviews, students were asked to rate, on a 0-10 scale, their interest and enjoyment in being involved in science activities, their motivation to continue their study of science, and their view of the importance of science in society. They were asked to describe their senior science subject (with the exception of Year 8 students), career, and/or tertiary course thoughts and their view of scientists and the role of science in society. They were also asked to describe any changes in their ideas about science, and participation in science activities, since the previous interview. Each enrichment or extracurricular science activity in which they had participated was addressed individually, and not all students did all activities.

At least 1 week prior to their final interview, each student received a copy of a *Graphs of Retrospective Trends* worksheet (Figure 1) developed by the first author. Students were asked to reflect upon trends in their interest and enjoyment in being involved in science activities, their motivation to continue their study of science, and their view of the importance of science in society during the previous 3 years and to draw, on their worksheet and in their own time prior to interview, line graphs to represent trends in each of these variables during that time. During each interview, these graphs were used to focus questions.

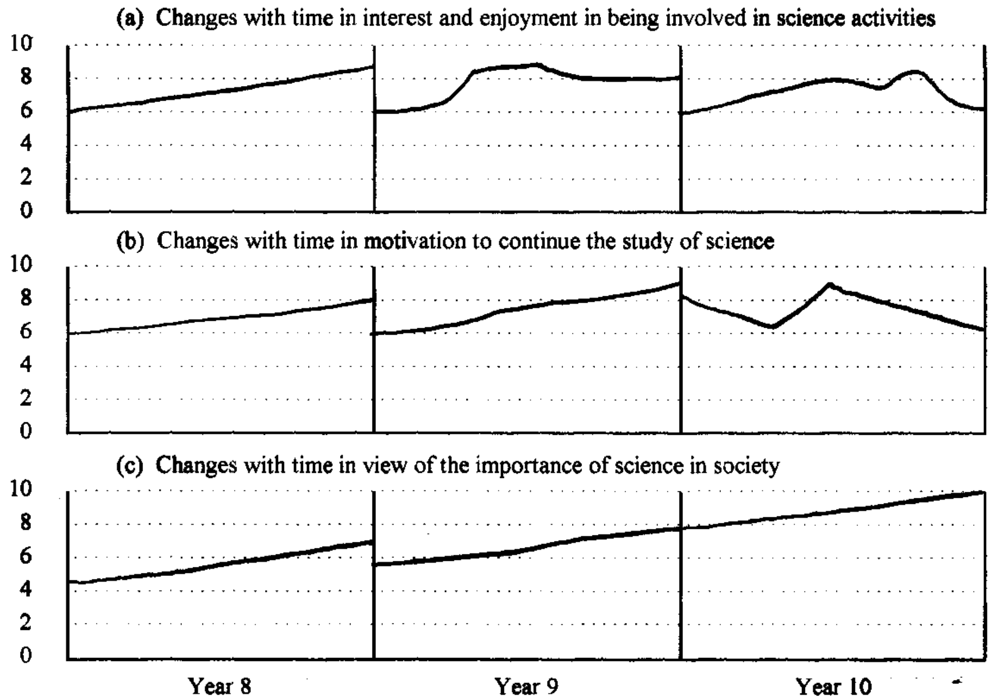

Figure 1. Example of a *Graphs of Retrospective Trends* worksheet.

Information was also collected about students' participation in science activities, their reasons for choosing to participate or not participate in extracurricular activities (survey), and their achievement, effort, and conduct and cooperation in each subject studied (school record cards). Data were first used to produce a case study report for each of the final 20 sample students. Then, each enrichment and extracurricular science activity was considered in turn in terms of its effect on each dependent variable: students' interest and enjoyment, motivation to participate in science, and perceptions about science and scientists.

Results

Because there was a strong positive relationship between students' interest and enjoyment in being involved in science activities and their motivation to participate in science, these two dependent variables are discussed jointly. In this section, each kind of activity is briefly described and discussed.

Competitions. Competitions comprise the Australian Schools Science Competition (Years 8 - 12), National Chemistry Quiz (Years 10 - 12), Queensland School Geology Competition (Year 11), and Biology Olympiads (Year 11). In all cases, questions are set, and answers are marked, externally to schools.

Participation in the Australian Schools Science Competition and the National Chemistry Quiz both resulted in overall short-term increases in students' interest and enjoyment in being involved in science activities and/or their motivation to continue to participate in science, most often as a result of students receiving awards. "I have done well in them or reasonably well [a high distinction, credit, distinction, and credit, respectively, during Years 7 to 10] so that makes me feel like I've accomplished something and that I can do the science subjects so it motivates me a bit more to go and study harder and longer." Other reasons for this positive effect included interesting questions, novel content which increased curiosity and was related to everyday-life experiences, positive reinforcement or broadening of future career opportunities in the sciences, broadening a student's view of the breadth of topics which constitute science, not finding the quiz too difficult, and broadening a student's view of the role of science in society.

Receiving an award did not guarantee a positive effect, and a positive effect was usually experienced only in conjunction with a students first entry, unless a subsequent entry resulted in the student receiving either an award for the first time or a higher award. Neither competition provided any negative effects on students' interest, enjoyment, or motivation.

While the Biology Olympiads had no effect on the interest, enjoyment, or motivation of the two students who chose to participate, the difficulty of the questions on the Queensland School Geology Competition (Senior Division), although having no effects on students' interest and enjoyment, influenced three of the nine students not to pursue geology in the future. "[I] didn't want to go into geology" because it "put me off with all the words they used . . . it didn't make me feel very smart, that's for sure."

While the National Chemistry Quiz, Queensland School Geology Competition, and Biology Olympiads had no effects on students' perceptions about scientists, the Australian Schools Science Competition did have a first-sitting-only effect of broadening some students' perceptions about the type of work in which scientists can be involved; an effect which was much more pronounced with boys than girls.

The first sitting only of the Australian Schools Science Competition broadened some students' perceptions about, and as a result often increased their view of the importance of, the role of science in society. "I found out that, like I thought science was just mixing chemicals together and all that but it's on, the animal kingdom, plant kingdom, the respiratory system and all that, the gases in the atmosphere and all that." "[Science can] prevent bad things from happening." While the National Chemistry Quiz had the same effect but far less frequently (even considering that students had fewer opportunities to sit for it), the Queensland School Geology Competition had no effects on students' views about the role of science in society and the content of the Biology Olympiads did have a positive effect on one student. Table 1 summarises the effects of competitions on students.

Table 1
A Summary of the Effects of Competitions on Students

Activity	Year offered	Dependent variable		
		Interest, enjoyment, and motivation	Perceptions about scientists	Role of science in society
Australian Schools Science Competition (n[a] = 20)	8-12	Overall positive effect, most often as a result of receiving an award, but usually in conjunction with first sitting only	First-sitting-only effect of broadening some students' (mainly boys') perceptions about the type of work in which a scientist can engage	First-sitting-only effect of broadening some students' perceptions about, and increasing their view of the importance of, the role of science in society
National Chemistry Quiz (n = 17)	10-12	As for Australian Schools Science Competition	No effects	As for Australian Schools Science Competition, but far less wide spread
Queensland School Geology Competition (n = 9)	11	Difficulty of questions led to overall decline in motivation towards geology	No effects	No effects
Biology Olympiads (n = 2)	11	No effects on either student	No effects	Some content had a positive effect

[a]Denotes the number of sample students who participated in the activity.

Excursions. Excursions required students to travel to off-college-campus venues, and those used at Glendale College comprise the Science Contest (to view the annual Queensland Science Contest entries) and Planetarium Excursions (Year 8), Vacation Science Tours (2-day bus tour of science being applied in the community, including visits to businesses and research groups) (Years 8 - 11), the *Sciencentre* (Queensland Museum *Sciencentre* interactive exhibits) and Mine (Ebenezer Coal Mine) Excursions (Year 9), A.S.I.A. Science Summer School (now the Siemens Science Experience) and USQ Seminar (1-day engineering and surveying seminar) (Year 10), R.A.C.I. Schools' Lecture (Year 11), and CSIROSEC Excursion (structured physics experiments) and Youth Physics Lecture (Year 12).

Table 2 summarises the effects of excursions on students. Seven activities made a significant positive impact on students' interest and enjoyment in being involved in science activities and/or their motivation to continue to participate in science: the Science Contest Excursion, Planetarium Excursion, *Sciencentre* Excursion, USQ Engineering and Surveying Seminar, Vacation Science Tours, A.S.I.A. Science Summer School, and R.A.C.I. Schools' Lecture. In the case of five activities involving a total of five different students, the positive effect on students' interest and enjoyment in being involved in science activities and/or their motivation to continue to participate in science was still evident 1 year later. Reasons for this positive influence of excursions included that it was interesting and enjoyable, showed that science can be fun, involved novel experiences and hands-on activities, could find things out for oneself, included some exhibits related to work father was doing at home, made one student think that if he had some good ideas he could perhaps work on similar inventions after his school years, broadened perception of the type of work (and hence future opportunities) associated with science, demonstrated that anyone, as opposed to a "brain" only, can do science (two students), much was learned from it, caring personnel, and gave ideas for their Investigation the following year. In contrast, the Mine Excursion, CSIROSEC Excursion, and Youth Physics Lecture made little or no impact.

The most prevalent effect of excursions on the junior sample students' views of scientists was that they broadened some students perceptions about the type of work in which scientists engage; an effect more widespread for the Science Contest, Planetarium, and Mine Excursions and possibly the USQ Seminar than for the *Sciencentre* Excursion. In contrast, the excursions involving senior students had, as their major common effect, and for particularly the Vacation Science Tours, A.S.I.A. School, and R.A.C.I. Schools' Lecture, a negating of the stereotypical image (and associated reinforcement of the normality) of scientists. "The A.S.I.A. School changed it [his view of scientists] a lot because, um, the people who came in to lecture us were, um, really nice, friendly, um helpful and they were all really different people, not just the set image of glasses and all that kind of stuff . . . labcoat." Other effects of these activities on students' perceptions about scientists were as follows: they work hard (two students), work towards making the world a better place, work harder than previously thought, use interesting equipment, do more interesting work than previously thought, are engaged in a broader range of work than previously thought, and they must be pretty brainy.

The most common effects of excursions on students' perceptions about the role of science in society were that they broadened some students' views about the contribution of science to society, often also increasing students' views about the importance of science in society. This applied particularly, for junior students, to the Science Contest, Planetarium, and Mine Excursions. For the senior students, this effect was most pronounced for the Vacation Science Tour, A.S.I.A. School, and R.A.C.I. Schools' Lecture, with the CSIROSEC Excursion and Youth Physics Lecture having no effects in this area.

Practical work. These activities, requiring students to engage predominantly in practical work, comprise Evening Science (teacher-supervised student-initiated evening work in a laboratory) (Years 8-11), Science Club (one 50-minute period each week additional to normal science classes) (Years 8-10 and 12), the Investigation (student-designed practical scientific investigation) (Year 9), Primary

Table 2

A Summary of the Effects of Excursions on Students

Activity	Year Offered	Dependent variable: Interest, enjoyment, and motivation	Perceptions about scientists	Role of science in society
Science Contest Excursion (n = 9)	8	Positive effect on the interest and enjoyment of most students and on the motivation of some students, most often because it was interesting and/or enjoyable	Broadened perceptions of some students about the type of work in which scientists engage	Broadened some students' perceptions about the contribution of science in society
Planetarium Excursion (n = 9)	8	As for Science Contest Excursion	As for Science Contest Excursion	As for Science Contest Excursion
Sciencentre Excursion (n = 16)	9	As for Science Contest Excursion	As for Science Contest Excursion for 1 junior student, plus showed work of scientists can be interesting and scientists must be "brainy" in case of 1 junior student each	Effect as for Science Contest Excursion but on 1 junior student only
Mine Excursion (n = 10)	9	Positive effect on some students	As for Science Contest Excursion	As for Science Contest Excursion
USQ Seminar (n = 3)	10	Positive effect on 2 of the 3 boy volunteers because it was interesting	As for Science Contest Excursion but on 1 student only	Effect as for Science Contest Excursion but on 1 student only

Table 2 (cont'd)

Activity	Year Offered	Dependent variable: Interest, enjoyment, and motivation	Perceptions about scientists	Role of science in society
Vacation Science Tour (n = 5)	8-11	Positive effect on the interest and enjoyment and/or motivation of most volunteers because they were interesting and broadened view of future opportunities in science	Negated stereotypical image of some students	Increased and/or broadened or reinforced perception of most students
A.S.I.A. School (n = 3)	10	Positive effect on both the interest and enjoyment and the motivation of all volunteers, mainly because it was interesting, fun, and enjoyable	Negated stereotypical image or reinforced normality of scientists for all students	As for Vacation Science Tour
R.A.C.I. Lecture (n = 7)	11	Positive effect on the interest and enjoyment and/or the motivation of most students, mainly because it was interesting	Reinforced normality for some students, but reinforced stereotype for 1 student	As for Vacation Science Tour
CSIROSEC (n = 7)	12	Positive effect on motivation of 1 student only because it was interesting	Reinforced normality for 1 student only	No effects
Youth Physics Lecture (n = 7)	12	No effects	No effects	No effects

Interface (students prepare a scientific demonstration and perform and explain it to a small primary audience) (Year 10), Work Experience (typically for at least 1 week during a vacation period) (Years11 and/or 12), and the Biology, Chemistry, and Physics Investigations (student-designed practical scientific investigations) (Year 12).

The practical work activities which had the broadest positive short-term effects on students' interest and enjoyment in being involved in science activities and/or their motivation to continue to participate in science were Evening Science, the Investigation (Year 9), Primary Interface, Work Experience, and the Chemistry Investigation. Reasons included finding it enjoyable, interesting, a challenge and fun, observing primary student visitors enjoying it, increasing understanding in an area of interest, having own choice of question and method, the sense of achievement associated with seeing others learn, student choice of what to do, the hands-on nature of the activity, reinforced a desire to study in a particular area, and opened a possible tertiary option.

Very few students experienced negative effects associated with Evening Science and the Investigation. Reasons included that even when one student sought help with physics problems she couldn't do them and this made her feel "degraded, stupid, dumb," and that another student found it difficult to think of something to do for his Investigation, found it a big task, intimidating, he made mistakes, didn't enjoy doing it, and had to work during holidays. While the Biology Investigation increased the interest and enjoyment of one student only of seven (because she enjoyed her chosen work in which she was interested and about which she was curious), Science Club had no effect on any of the eight students who participated at some time and the Physics Investigation decreased the interest and enjoyment of one of the seven students. This was because he found his work annoying, boring, and repetitive, other students tampered with his apparatus, and he regarded his results as "lousy".

Evening Science, the Primary Interface, and the Investigation all broadened the perception of some students about the nature and variety of the work of scientists, while Work Experience negated the stereotypic image of two girls of the seven students who participated. These two girls also said Work Experience demonstrated that the research-oriented lifestyle of a scientist was interesting, and that scientists had many different attitudes to life and work, respectively. Science Club and the three senior science investigations had no effects on students' perceptions about scientists.

Evening Science, the Primary Interface, the Investigation, and Work Experience broadened the perception of a significant number of students about the role of science in society and, in the case of the latter two activities, this also often resulted in an increase in the view of the importance of science in society.

> Um, well just doing something that doesn't seem very scientific [at the time] such as insulation, um, well basically made me realise that, you know you can basically apply science to just about anything so, um so, well just made me realise that science is pretty important in society.

Work Experience showed how forensic evidence such as hair and fingerprints are used, new technologies which are improving medical standards, the importance of grain breeding research for the agriculture industry, and the work of a veterinary surgeon.

The other practical work activities, Science Club and the three senior science investigations, had no effects on students' perceptions about the role of science in society. Table 3 summarises the effects of practical work activities on students.

***Guest Evenings*.** Here, the effects of the Evening Science With a Guest activities, comprising visits to the college by practitioners in cereal chemistry, flora and fauna research, insect control and field ecology, sorghum breeding, electrical engineering, weather-satellite imaging, mass spectrometry and scientific instrumentation, and veterinary science are addressed.

Evening Science With a Guest activities increased the interest and enjoyment and/or motivation of 7 of the 10 students (8 junior and 2 senior) who chose to participate, mainly as a result of the topics covered in the case of junior students and because it reinforced a future tertiary path for one senior student. "I've been interested in veterinary science and . . . Dr Miller's experience was pretty weird, in all the places that he'd been to and all the things he'd done so it just show [sic] you, urn, the diverseness of the field, how you can splinter off into different directions and how interesting some of those were."

Participation in Evening Science With a Guest activities influenced 8 of the 10 participants' perceptions about scientists, most often because the evenings broadened students' views about the type of work in which scientists are involved and also, to a lesser extent, because they reinforced or enhanced a students view about the normality of scientists:

> It showed me that, um, you don't have to be the most educated or intellectual person in the world to be involved [in science], anyone can be . . . people reckon that they're just a freak of nature sort of thing that's why they're so smart but they're not. They're just normal human beings who've got ambition.

In the case of two students, this activity reinforced or demonstrated the participation of women in engineering.

Evening Science With a Guest broadened the perceptions of nearly all junior students about the role of science in society, also increasing the view of three of the eight junior students about the importance of science in society. There were no effects on the two senior students in this area.

Conclusions

This study has shown that, overall, providing both junior and senior students with opportunities to participate in enrichment and extracurricular science activities can increase, at least in the short term, both their interest and enjoyment in being involved in science activities and their motivation to continue to participate in science, change their perceptions about scientists, and broaden their perceptions about the role of science in society and/or increase their view about the importance of science in society. The most prominent activities, in terms of their overall positive effect across all dependent variables (i.e., interest and enjoyment, motivation, scientists, and science in society), were the A.S.I.A. Science Summer School, Evening Science, Evening Science With a Guest, Vacation

Table 3
A Summary of the Effects of Practical Work Activities on Students

Activity	Year offered	Dependent variables: Interest, enjoyment, and motivation	Dependent variables: Perceptions about Scientists	Dependent variables: Roles of science in society
Evening Science (n = 6)	8-12	Positive effects for most students; a small negative effect on 1 student's motivation only	Broadened perception of some students about the nature and variety of the work of scientists	Broadened perception of some students about the role of science in society
Science Club (n = 7)	8-12	No effects	No effects	No effects
Investigation (n = 15)	9	Increased both the interest and enjoyment and the motivation of many students, often because it was enjoyable, and a negative effect in both areas for 2 students	As for Evening Science	As for Evening Science, often increasing view as well
Primary Interface (n = 12)	10	Increased interest and enjoyment of most participants, and motivation of some, mainly because it was enjoyable and fun but also, for 2 students, seeing the primary students enjoy it or learning from it	As for Evening Science	As for Evening Science

Table 3 (con't)

Activity	Year offered	Dependent variables: Interest, enjoyment, and motivation	Perceptions about Scientists	Roles of science in society
Work Experience (n = 7)	11,12	Increase in interest and enjoyment of some students, increase in motivation of nearly all students, and decrease in motivation (in a specific area only) of 1 student	Negated stereotypic image of 2 girls	Increased view of most participants because it broadened their view
Senior Science Investigations				
Biology (n = 7)	12	Increase in interest and enjoyment of 1 student only	No effects	No effects
Chemistry (n = 10)	12	Increase in interest and enjoyment of many students and motivation of some students	No effects	No effects
Physics (n = 7)	12	Decrease in interest and enjoyment of 1 student	No effects	No effects

Science Tours, and the Primary Interface. These represent excursions, practical work, and guest evenings, but not competitions.

Attention has been drawn to the need for more Australian students to continue to participate in science (Eastwell, 1998). In addition to the five activities identified above, this study shows that student participation in the following activities also made positive contributions towards achieving this goal: the Australian Schools Science Competition, National Chemistry Quiz, Year 9 Investigation, Work Experience, Chemistry Investigation (Year 12), USQ Seminar, R.A.C.I. Schools' Lecture, and excursions to see the Queensland Science Contest entries, to the Planetarium, and to the *Sciencentre*. Hence, learning experiences from all four categories of activity motivated students to continue to pursue science.

Little can be concluded from the result that Science Club had no effects on students. Only one junior student chose to participate and five of the six senior participants used this activity simply as an additional opportunity to work on one or more of their senior science investigations, so associated effects are probably reported in conjunction with the latter. The other senior student used Science Club to practise chemistry titrations.

It is recognised that the results of this study are specific to this group of students, partly because it was a sample of convenience (and therefore having potentially limited external validity), partly because it was a longitudinal study and there are additional factors which might threaten internal validity, such as attrition and changing characteristics of the school (even the rural recession and declining student numbers), and partly because some activities, like lectures and guest evenings, are so dependent on the person presenting that one cannot generalise from one activity to the next. For example, while the R.A.C.I. Schools' Lecture made a significant impact on students' interest, enjoyment, and motivation, the Youth Physics Lecture had no effect in these areas despite the fact that six senior students attended both. While all these things were out of the control of the researcher, so little was known in the area that a detailed longitudinal study must contribute at least some baseline knowledge that serves two purposes. First, the study gives other teachers some guidance of factors to consider when evaluating the cost/benefit of activities and second, the study provides knowledge that other researchers can build upon. However, although the findings of this study may not be generalisable to groups of students whose characteristics have not been investigated, the findings may be relevant to similar populations exposed to similar experiences.

Recommendations and Implications

What, then, are some implications of the conclusions of this study for teachers and other science educators? The study has shown that different activities may have different effects on the affect of different students. It is hardly surprising to find that different things affect different people in different ways, and underlines the need to provide students with the opportunity to participate in a variety of science activities.

Cost/benefit effectiveness. Which activities can be recommended on a cost/benefit basis, where cost includes time required of school personnel as well as money? This study suggests that, from the point of view of making significant positive impacts on students across all dependent variables (i.e., increasing their interest and enjoyment in being involved in science activities and/or their motivation to continue to participate in science, and influencing their perceptions about scientists and about the role of science in society), the A.S.I.A. Science Summer School is highly attractive. This activity requires minimal input from school staff, but the number of students who can attend is limited and each attending student does incur a charge. For a little more time commitment from teachers, Evening Science and Evening Science With a Guest activities are highly recommended, low-cost opportunities (provided invited guests can be engaged at no, or little, financial expense). Where staff are able to make a greater time commitment, the Primary Interface and Vacation Science Tour are also highly recommended, although the latter can require students to pay for accommodation and bus expenses.

If an emphasis was placed on motivating students to continue to participate in science, the Australian Schools Science Competition, National Chemistry Quiz, and Work Experience are readily implemented, low-cost recommendations (although Work Experience placements may require a time commitment by staff). However, because the junior students in this study were a generally able group, this recommendation about the positive effects of the competitions may not transfer to junior student populations in general. Only one girl in the junior sample could be considered lower-achieving, and the Australian Schools Science Competition had a small positive effect on her motivation in Year 8 only when she was achieving at a C level. Hence, the effects of participation in these competitions on middle and lower-achieving junior students warrants further research. Given the positive influence of students' first entry to these competitions, students achieving in their science studies at a high level (and possibly middle- and lower-achieving students, pending the findings of the research just mentioned) might be strongly encouraged to participate at least once in each competition. Subsequent entries could then be optional, although their likely positive impact on the interest, enjoyment, and motivation depends on students obtaining their first, or a higher, award.

Given the positive effect of receiving an award in competitions, it is tempting to recommend that awards for outcomes from science activities in general be made available on a liberal basis, but not so liberal as to devalue an award or give students an inflated perception of their aptitude for a subject. However, while awards in these competitions were made by bodies outside the school, internal awards for the Year 9 Investigation had no effects. It may be that external awards make a greater impact on students than internal awards.

The USQ Seminar, R.A.C.I. Schools' Lecture, and Science Contest, Planetarimn, and *Sciencentre* excursions have been shown to be motivating influences on students, although each could involve travel costs to students, depending upon where students live. For a greater commitment by staff, the Year 9 Investigation and Chemistry Investigation also motivated students.

There appears to be little for students to gain from entering the senior section of the Queensland School Geology Competition in the form that it took in 1993. In fact, it was the only activity to make a significant negative impact on students; on their motivation to participate further in geology. Organisers of any future Queensland School Geology Competition are advised to include further process, or reasoning, type questions in their senior paper, at the expense of questions requiring knowledge which students are unlikely to have. By testing what students can do, as opposed to what they don't know, the competition is likely to influence students far more positively.

Enhancing the effectiveness of investigative projects. On the basis of the findings, some suggestions can be made for enhancing the affective outcomes from activities such as the Year 9 Investigation.

First, a broader range of stimulus material, to assist students with their choice of project, needs to be provided. Since these investigations were completed, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) has produced the CREST Awards education program. This program provides a structure for carrying out a science or technology research project, gives a large number of examples of possible project topics, and provides an excellent basis for student investigations. Second, consistent classroom checks on student progress during their investigations, coupled with appropriate feedback, can encourage students to make steady progress, rather than “leaving it to the end,” and avoid them setting unrealistic goals. Third, linking the out-of-school time commitment associated with projects such as these with better use of in-class time (or other in-school opportunities, such as Science Club or Evening Science, in the case of Glendale College) will encourage students to gain the satisfaction associated with completing a satisfactory project.

Enhancing the effectiveness of excursions. Two features of the Mine Excursion may have curtailed stronger positive outcomes from it. The activity was a highly structured one in which students participated passively, and this is less likely to promote desirable affective outcomes than active participation with at least some less-structured opportunities (Eastwell, 1998). While the structure of the visit in this study was determined by the hosts and was not negotiable, organisers of future programs for visiting schools should consider ways to increase student participation during the visits.

Enhancing students’ perceptions about science and scientists. The structure of questions in competitions provides opportunity to broaden the perceptions of students about the type of work in which scientists engage, and to promote the normality of scientists. Perusal of competition papers supports the finding that the Australian Schools Science Competition appears to be missing the latter opportunity, and that the National Chemistry Quiz and Queensland School Geology Competition is missing both. The National Chemistry Quiz questions, for example, are characterised by an impersonal context. By including appropriate graphics and text with at least some items on the papers, the competition organisers appear to be in a position to influence students’ perceptions more broadly.

Missed opportunities also occur in excursions to places such as the *Sciencentre.* There appears scope for the printed stimulus material supplied at each *Sciencentre* workstation to broaden students’ perceptions about the nature and variety of the work of scientists and to negate negative stereotpical images of scientists. In addition to appropriate pictorials and text, the *Sciencentre* workstations might also incorporate some audiovisual material. Of course, care would need to be taken to ensure that such attempts did not result in so much information that students were confused, or that the workstations became boring.

Some science activities increased the view of many students about the importance of science in society. However, the Queensland School Geology Competition, the *Sciencentre* Excursion, and, to a considerable extent, the National Chemistry Quiz had little influence on students’ perceptions about the role of science in society. In the case of the National Chemistry Quiz, for example, links between science and society are implied in almost one quarter of the questions, but without the link being made explicit. These activities appear to be missing a valuable opportunity to make a far broader impact on students’ views about the breadth and importance of the contribution of science to society. Modification of at least some test items, and stimulus materials at workstations, along the lines suggested in relation to perceptions about scientists above, aimed at placing them in some form of life-role context which exemplifies the importance of science to our nation's social and economic well-being, would appear beneficial.

It seems that teachers, by encouraging students to adopt a vision or goal for future studies or a career, can facilitate an increase in students' motivation to continue to participate in science in cases where this vision involves science. This study has shown that participation in enrichment and extracurricular science activities can assist in the adoption of such visions and goals by broadening students' awareness of potential science-based careers.

Many enrichment and extracurricular science activities can impact positively on students' attitudes to, and about, science and scientists. Implemented thoughtfully, they can make a valuable contribution to school curricula.

References

Beasley, W., Butler, J., & Satterthwait, D. (1993). *Senior sciences future directions project: Final report.* Brisbane, Australia: Board of Senior Secondary School Studies.

Eastwell, P. H. (1998). *The influences of a program of enrichment and extracurricular activities on the affect of secondary science students.* Unpublished doctoral dissertation, Curtin University of Technology, Perth.