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The Impact of an Integrated Curriculum on Student Attitudes about Science and Learning of Electricity Concepts

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Abstract: Integrated curricula have been promoted as being able to provide the three-way benefit of improving students' conceptual understanding of science, the application of science understanding to real-world contexts, and students' attitudes to science. However, little research has been conducted about the impact of an integrated curriculum on all three of these factors. The purpose of this research was to examine the implementation of an integrated project and evaluate students' conceptual understanding of electrical circuits, links made to the real world, and student attitudes to their learning. The exploratory case study was conducted in a Year 8 academic extension class and students were required to research, plan, design and build a small-scale house with a working electrical lighting system. The project also included activities from all other subjects including mathematics, English, computing and society and environment. Data collection included pre and post project student interviews and surveys about conceptual understanding of electricity and attitudes and classroom observation and teacher interviews. The results indicated that student learning about electricity was evident, that students were able to apply their knowledge to the house building, integrate knowledge from other sources besides school, and their attitudes to science were positive.

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The *Curriculum Framework* in Western Australia (Curriculum Council, 1998) supports the integration of science with other learning areas. The fifth principle of the *Curriculum Framework* is "Integration, breadth and balance" and states that, "Effective education enables students to make connections between ideas, people and things…" and "encourages students to see various forms of knowledge as related and forming part of a larger whole" (Curriculum Council, 1998, p. 17). While the intent of this principle is clear, research suggests the science that is taught in schools in Australia does not often reflect the intended curriculum (Goodrum, Hackling & Rennie, 2001).

Science education in Australia and other developing nations is widely considered to be is in crisis, not because students are failing, but because they are not interested in or engaged by science as it is currently taught in schools (Tytler, 2007). A large scale study into the status and quality of teaching and learning of science in Australian schools (Goodrum, Hackling & Rennie, 2001) found that "when students move to high school, many experience disappointment, because the science they are taught is neither relevant nor engaging and does not connect with their interests and experiences" (p. viii). A potential solution to this problem of student engagement may be the provision of more integrated curricula with courses and lessons that help students to understand the connections between science, other learning areas and the real world outside school.

Some commentators argue that students who participate in integrated curricula are better able to transfer knowledge to different contexts, more motivated, and more likely to learn higher order thinking skills (Hargreaves, Earl & Ryan, 1996). Moreover, the content of most integrated curricula is considered to more closely reflect students' experiences in real life outside their school classroom and hence, enhance engagement (Beane, 1995). Conversely, others argue that it is important to maintain the integrity of the disciplines and without in-depth consideration of subject specific problems and issues, students will not learn the specialised skills and knowledge that underpin our entire educational system (Gardner, 2004; Leonardo, 2004; Schoenfeld, 2004). While integrated curricula may be a potential solution to declining student attitudes to science, there is still debate about the nature and scope of the benefits (Czerniak, 2007) and such benefits are not easily measured.

The problem that we address in this paper is that curricula that are delivered in an integrated way are rarely evaluated in an holistic manner. Researchers, like Hurley (2001) for example, only examine outcomes in terms of students' science achievement as measured on conceptually-based tests traditionally used to determine achievement in highly disciplinary teaching and learning contexts. Other researchers, like Hargreaves Earl and Ryan (1996), examine learning in terms of factors such as motivation and higher order thinking skills that are not easily measured by traditional tests. Indeed, we have promulgated this problem with some of our research focussing simply on students' conceptual understanding in integrated learning environments (Venville, Rennie, & Wallace, 2003). Other aspects of our research has incorporated less traditional perspectives by considering learning as students' ability to transfer ideas from one context to another, students' general motivation and perception of the relevance of their school work (Venville, Wallace, Rennie, & Malone, 2000) and students' use of sources of knowledge (Venville, Rennie, & Wallace, 2004), but has ignored students' conceptual learning.

Purpose of the research

This research is situated in one class of Year 8 academic extension students who participated in a single term (10 week) integrated science project about a model house. The students learned about electricity in science and were required to research, design and construct the model house with a working electric light system. Other curriculum areas examined related topics that brought different disciplinary perspectives to explore ideas directly and indirectly related to the model house project. (The project is described in more detail below.)

The purpose of the research was to attempt to take a more holistic approach to evaluating the outcomes of the model house project by not only examining the conceptual learning that took place, but also the students' ability to apply their knowledge and to make connections to their real world, as well as their attitudes to science and the integrated project. More specifically, the research questions were:

1) How did the students' understanding of electrical circuits change over the period of the project?
2) Were students able to demonstrate application of their understandings to their own real world contexts?
3) What were the students' attitudes to the project?

Defining an integrated curriculum

The issue of defining curriculum integration is an epistemological conundrum because knowledge in the real world is holistic, and the division of knowledge into subjects for teaching and learning in schools is an historical, practical method of curriculum delivery (Hatch, 1998). The conundrum exists because most people experienced a traditional education with highly discrete disciplines. As a result, we tend to think of knowledge as naturally being made up of discrete learning areas, or subjects like science. Consequently, curriculum integration is considered, by many, as a step beyond that status quo, facilitating learning across learning areas through teaching strategies such as themes, projects, problems and/or issues that are interdisciplinary. Several researchers have described a continuum, at one end are curricula that are considered to be highly integrated and at the other end are curricula that are considered to be highly disciplinary (Drake, 1991, 1998; Fogarty, 1991).

In contrast with the view that an integrated curriculum is about bringing the subjects together, Beane (1995) defines integration as a curriculum that begins with "problems, issues and concerns posed by life itself" and that the central focus of curriculum "is the search for self- and social meaning" (p. 616). For the purpose of this research we used a definition of curriculum integration that includes the broad spectrum of curricula that we have observed, and that have been described by teachers and in the literature, as integrated.

> An integrated curriculum enables students to look toward multiple dimensions that reflect the realities of their experiences outside and inside school.

This definition encompasses an holistic view of knowledge and, at the same time, includes some teaching and learning practices that might be considered discipline-based. Moreover, this definition enables the disciplines, including science, to be considered a source of explanation and inquiry to answer and explore real life issues relevant to learners.

School context

Mossburn School[1] is a small, religious, independent, fee paying school with students from Year 1 to Year 12 (ages 5 – 17 years). The integrated project about a model house that is the focus of this research was initiated in the Year 8 academic extension class two years prior to the data collection. The academic extension class is composed of the top achieving science students in the year cohort. Two teachers began the project by integrating concepts from their classes of mathematics, computing and science. Claire taught the science whilst her sister, Jane, taught the mathematics and computing courses. The project was expanded in the third year (the year of data collection) to include more learning areas and involve more teachers. In this year, Claire was not involved in teaching the class and, as she had a more administrative role in the school, she became the project coordinator. In this role, Claire was instrumental in drawing together the teachers and managing the project throughout the term. Claire's role also was to help the teachers with the integration of the activities and, at the same time, ensure that they were meeting the assessment outcomes for their respective subjects. The students participated in the integrated project in addition to their regular classroom activities in each subject area. At the end of the term, all Year 8 students participated in exams in all their learning areas.

Project description

The project consisted of a series of interrelated subject tasks from each learning area, rather than a single, holistic project (see Table 1). The Year 8 extension teachers taught in their specialised subject areas, however, two meetings before the start of the topic and two subsequent meetings during the term ensured the teachers were familiar with all aspects of the project and the outcomes being sought in the other learning areas. Some subject areas involved the students in tasks closely related to the model house project (e.g. computing – see Table 1), while others were less integrated (e.g. physical education – see Table 1). Moreover, differing levels of commitment amongst participating staff members were observed, some were engaged and interested, while others were observed to be less focused on the integrated model house project.

[1] Pseudonyms have been used throughout this paper

Table 1: Student tasks required by each learning area teacher for the integrated model house project

Subject	Task
Science	Students were required to design and build a model house of balsa wood and cardboard. Once built and painted students installed a working parallel circuit of lights with switches. The project was secondary to the teaching of the core concepts of electricity and was fitted around these lessons.
English	Students were required to write a report using the data collected from other learning areas with a focus on the process of report writing as presented in a poster. The teacher also used class time to help students reflect on their tasks in other subject areas and consider how they could be better collaborators.
Arabic Studies	Students were required to complete one of two tasks, the first was to draw and label a house using Arabic terms, the second task for more able students was to write a newspaper advertisement in Arabic describing a house for sale.
Islamic Studies	Students were required to prepare a talk to discuss factors, "which make a happy Islamic home" considering the values of Islam and how these values were enacted in their homes.
Computing	Students were required to use a computing program they were unfamiliar with, called "SKETCHUP" to design and create the floor plan and external features of their house.
Mathematics	Students were required to draw a scale drawing of a house and connect to the council websites to determine the council rates. The project was secondary to the teaching of the core mathematics concepts and was fitted around other lessons.
Society and Environment	Students were required to research the history of houses and how housing has changed over the ages. The Society and Environment teacher often provided students with time during their classes to work on the house building providing students had completed their tasks for that day.
Physical Education	Students were required to prepare an eating and exercise plan for five weeks of term that promoted healthy living.

All Year 8 classes participated in common assessment tasks at the end of the term in which the project was conducted. As a consequence, all project tasks and activities in all learning areas had to be consistent with the Year 8 curriculum and common assessment tasks so that students were not perceived to be disadvantaged in any way.

Science lessons were completed within the normal timetable with the students learning about the theoretical aspects of electricity before participating in the model house project. The students were provided with a single 9-volt battery, three globes, a switch, balsa wood, cardboard and paints, if they required further material it was to be brought from home. Students started the construction of their houses slowly with continuing negotiation of task allocation within their groups. The groups of four or five students were all the same sex; this was a reflection of the culture of the school (all other classes besides the extension were gender segregated).

Research Design

The design of this research was an exploratory case study conducted in one Year 8 academic extension class in one school. Several forms of data were collected to answer each of the research questions and to strengthen the rigour of the case study. The approach to data collection and analysis is summarised in Table 2. The forms of data collection included surveys and student and teacher interviews. In order to broaden the data collection and develop an holistic view of the model house project, the researcher also attended meetings held by the teachers during the project, ten science lessons over the course of the term as well as four mathematics lessons, one English and one society and environment lesson. Field notes were taken during all meetings and classroom observations.

Table 2: Approach to data collection and analysis for each research question

Research Question	Data Collection	Data Analysis
1. How did the students' understanding of electrical circuits change over the period of the project?	● student pre/post open survey question (n=26) ● student pre (n=5) and post-interviews (n=26 in 8 groups of 3-4 students)	● pre/post-survey responses grouped, frequencies counted ● interviews searched for confirming and disconfirming evidence
2. Were students able to demonstrate application of their understandings to their own real world contexts?	● student pre (n=5) and post-interviews (n=26 in 8 groups of 3-4 students) ● teacher pre/post-interviews (n=5)	● student and teacher post-interviews searched for confirming and disconfirming evidence
3. What were the students' attitudes to the project?	● student post 9 item Likert scale survey (n=26) ● student post open survey question (n=26) ● student pre (n=5) and post-interviews (n=26 in 8 groups of 3-4 students)	● average scores and standard deviation for responses to Likert scale survey calculated. ● open survey question responses grouped, frequencies calculated ● post interviews searched for confirming and disconfirming evidence

Findings

The findings are presented in three sections that address each of the research questions. The first section examines students' learning and their conceptual understanding of electrical circuits, the second section considers students' ability to apply their knowledge to their life outside the classroom, and the final section examines students' attitudes to their studies with the focus on science.

Student learning about electricity

The electrical concept of "circuit" was the focus of this evaluation and a pre- and post-project open survey question required students to reason about the following question:

> In your house when one light goes out all the others stay on;
> Why do you think this happens?

It was expected that students who gave a correct response would distinguish between series and parallel circuits and explain that as most house circuits are parallel, when one globe burns out, there is a break in only that part of the circuit and other globes do not go out. These ideas were part of the content that was covered in the electricity component of the science course. Student written responses were coded into the categories presented in Table 3 and the number of responses and an example for each category were collected and tabulated.

In the pre-project survey students attempted to answer the question using their existing knowledge and expressing their answer using broad terms such as "static energy" and "energy wastage." Many students struggled to articulate their ideas and did not have the necessary language to explain their pre existing science knowledge. Six of the 35 responses from the 28 students interviewed prior to the project (17%) showed that the students had a correct conceptual understanding of circuits and electricity (Table 3). Another six responses indicated the students were able to correctly discuss the filament of a globe breaking when the globe went out, however, these students were unable to use this knowledge to answer the question (Table 3). A further six responses from the students (17%) showed they had some form of misconception including the notion that "fuses generated electricity." One student tried to avoid directly answering the question by reporting that without electricity, "we would probably be thrown into the darkest reaches of chaos" (pre survey student 9).

At the conclusion of the project, the students generally had a much better understanding of the concepts of electricity required to answer the question, with 21 of the 29 responses from the 26 interviewed students (72%) showing appropriate answers (Table 3). It can also be seen that the categories of responses are much narrower with the majority of 21 responses (72%) correctly articulating the concept of parallel and series circuits and only another seven responses expressing tangential ideas. In analysing the responses it can be seen that the students' grasp of scientific language also had improved as can be seen in the following example:

> The light in a house are in a parallel circuit … but if suddenly if one of the lights doesn't work the others still work because electricity goes from the negative to positive side of the power source so they travel in circles if one wire is cut it'll follow another route (post survey student 10).

Table 3: Student responses to survey question relating to a house light circuit.

Categories of responses	Pre-project student survey (n=28) Number of responses		Post-project student survey (n=26) Number of responses	
	n	%	n	%
Electricity through the wire (correct ideas) relating to parallel circuits	6	17	21	72
Globe filament specific # E.g. *The electricity heats a filament inside the bulb. When the filament has used to[sic] much it breaks (pre-project Student 3)*	6	17	3	10
Electricity through the wire (misconceptions) E.g. *Probably the charge of the light has finished and the electricity is not passing through the wires (pre-project student 24)*	6	17	0	0
Energy and sources of energy E.g. *I think that the reason behind this is that they are probably connected to different batteries with different amounts of power causing some to go out at different times. (pre-project Student 8)*	5	14	1	4
Globe general E.g. *It is simply because the particular light bulb has been exhausted. (pre project Student 7)*	4	11	0	0
Fuse	2	6	0	0
Static energy	2	6	0	0
Energy wastage	2	6	0	0
Other knowledge	2	6	2	7
Safety	0	0	2	7
TOTAL	35	100	29	100

The ideas expressed in the post project survey were confirmed by student comments during the post project interviews:

> I found out about parallel circuits I learnt that in our homes we use parallel circuits, if there is a fault in any part of the circuit all the others will still work. But in series circuit if anything goes wrong all of it goes wrong (post interview student 5)

> The lights in your house are connected in parallel circuit which means if one part of the circuit goes out the rest stay on. This is why in your house if one light goes off the rest stay on (post interview student 8)

Application of ideas to the real world

Research Question 2 focussed on students' ability to apply their knowledge and make links between their school science knowledge and their real life experiences. The interviews revealed that many students had discussed the project with family and friends, gathering advice and sharing their classroom experiences. This meant that their learning experiences were integrated with their life outside the classroom and that they did not see the teacher as the only source of knowledge for answering their questions and addressing their problems. In the post project interviews, students in six of the eight groups alluded to receiving advice from family members and friends and accessing internet and other sources. One student explained:

> I talked to my mum and dad, and my dad helped me to do the roof of the angle, and the shape and the design (post interview student 15).

Another student said:

> My dad's friend is a builder, so we always go and visit him. So he just helped me with some of the building regulations and stuff (post interview student 18).

One group of students also reflected that they had called on resources from outside school to complement the information presented by the teachers:

> Researcher: How did you find out about double glazing?
> Student 4: One of our lessons. Our teacher was talking about it.
> Student 5: And also we researched up the internet.
> *Later in conversation*
> Student 6: And for the regulations, I phoned the Stillmile shire.

The following comments indicate how students made links between their classroom and their experiences in the world:

> I liked the way how thunder is formed, learning about how electricity moves through objects, why birds don't get electrocuted when they sit on power lines (Post interview student 10)

> It gives us like a head start in life you know. It teaches us like skills, like cooperation and in some cases it can teach us individuality because you know, you need to do some things on your own (Post Interview student 24).

The science teacher, Dean, also noted the way that students make connections to their real world during the course of the project.

> The students were given an opportunity to apply the theory that they had learnt. The research and application definitely complemented their work." (Dean informal interview 1).

Student attitudes to the project

Students' attitudes towards the classroom activities were ascertained through a survey conducted at the conclusion of the model house project as well as during post-project interviews. The survey consisted of 9 items and students were required to respond on a five point Likert scale of strongly disagree, disagree, neither agree nor disagree, agree and strongly agree. The responses were scored with strongly disagree being given one point and strongly agree being given five points. The full survey, with average responses and standard deviations, is presented in Table 4.

Generally, the students responded in a positive way to the questions on the survey with students identifying that they perceived clear links between subjects (Table 4, Item 2), and that they enjoyed their science experiences during the term (Table 4, Items 3 and 9). They also reported positively that the science they had learnt was useful (Table 4, Items 1 and 5). It also can be seen that the students enjoyed working with their friends in their groups over the course of the project (Table 4, Item 4). It is interesting to note that although electricity is considered to be a complex topic for students to learn, these students reported that the topic was not difficult (Table 4, Item 8).

Table 4: Average student responses to questions about their experiences during the project. Twenty seven students completed the survey.

Question	Responses Average	Std
1. I thought that the integrated project provided me with useful information	3. 8	0.8
2. I thought that my subjects this term were linked together	4.1	1.0
3. I enjoyed the science that we did this term	3.9	1.0
4. I enjoyed working with my friends in class	4.1	1.1
5. I thought that the science we worked on this term would be useful for my life	3.9	1.1
6. I want to work on projects like this again	3.1	1.4
7. I feel that the most important part of my science learning is the notes	3.7	1.0
8. I feel that this project was very difficult	2.8	1.2
9. I really looked forward to my science classes this term	3.8	1.18

The written survey also included an open-ended question about the aspects of the model house project the students had liked the most. Fourteen (46%) of student comments in response to this question indicated the students liked conducting experiments, and seven comments (24%) indicated that it was aspects of electricity and circuits that the students had enjoyed (Table 5). One student commented:

> I really liked what it could when someone gets shocked (Post survey student 7).

Table 5: Students' responses to questions regarding the aspects of the project they had liked. There were a total of 29 comments from 27 students.

Category	Number of comments	% of comments
Liked performing experiments (general)	14	46
Electricity (interested in electricity and the specific activities performed)	7	24
Application of electricity	4	14
Notes/formula	2	8
Other	2	8

In the post project interviews some students said that they really enjoyed designing and creating the house model. One group of girls were really enthused with aspects of the project that they described in the following manner:

> ... we're going to build the wall here and this is gonna to be the, there's going to be a little door there, and this, our front yard where we're gonna paint it green and put little flowers, you know decorations (Post interview student 23)

Other students reported that it had been the collaboration and the group work they had enjoyed but this had also been challenging.

> ..it's been very enlightening, but um, especially the science part, because you know we have to do our own stuff and we had to be our own responsible person (Post interview student 23)
>
> If like –even if everyone has different ideas, you like find some way of putting them all together (Post interview student 24)

The collaboration and group work aspect of the model house project was also identified by the science teacher, Dean, as being a very important learning point for the students. He explained that students needed to negotiate responsibilities and forge the "development of team work and communication skills, designating of tasks and meeting deadlines" (Dean post interview).

Conclusion

The purpose of this exploratory case study was to attempt to take an holistic approach to evaluating the outcomes of the model house project by not only examining the conceptual learning that took place, but also the students' ability to apply their knowledge and to make connections to their real world, as well as their attitudes to science and the integrated project. The findings indicated that students in this class made considerable improvements in their conceptual understanding of electricity, particularly with regard to the concept of circuit, which was the focus of the science aspects of the model house project. The findings also indicated that students actively applied their scientific understandings when designing and building their model house. They crossed boundaries and utilised sources of knowledge outside the school, through the internet and contact with their families and friends to address problems and issues that arose through process of the project. Finally but importantly, the findings indicated that the students' attitudes to the project work were positive. They perceived links between the subjects being taught, they enjoyed working with their friends in class, they enjoyed the science related to the model house project and looked forward to science classes.

The findings of this exploratory case study are very important when we consider the issues in science education in Australia today. Australian students perform well on international tests of science conceptual understanding and scientific literacy compared with international averages, however, student attitudes to science are negative (Tytler, 2007). This case study has demonstrated that a carefully planned approach to curriculum that incorporates both disciplinary and integrated tasks, not only enriches students' conceptual understanding, but enables them to make links to their real world and develops positive student attitudes to science.

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