

Exploring the impact of pedagogic approaches in technology practice upon the construction of feminine identity

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Abstract

Females participate to a limited extent in science, engineering and technology (SET) industries that are central to innovation and building national economies. The causes of this under representation, in part, have their roots embedded in how females perceive school mathematics, science and technology subjects as being inconsistent with their gender identity. A participatory action research methodology was used to investigate the effect of two different pedagogical approaches for teaching middle school mathematics and science through technology practice on female students' attitudes to SET. Quantitative and qualitative data related to enjoyment, intention to undertake further such study, perceived usefulness and interest in career options involving SET, and perceptions of the investigative nature of the two approaches, were sought using, interviews, classroom observations, and a modified survey instrument. The findings indicated that female students responded in a more positive manner when careful scaffolding and the establishment of explicit linkages between the construction activity and mathematics principles were part of the pedagogical approach. In addition, there were specific types of projects that females found authentic. The implications of these findings for SET syllabus authors, pre- and inservice teacher educators, and classroom teachers are explored.

Keywords: *gender identity, pedagogy, attitudes, mathematics, science; technology*

Background

Currently, females comprise only 19 percent of the science, engineering and technology (SET) workforce (Barnett and Rivers, 2004). This may be, in part, because females need, but frequently do not receive, opportunities to engage creatively in ways that promote their interest in studying and working in technology based careers associated with the hard sciences (Ching et al., 1998). The under representation of females in science in the post-compulsory years of education, particularly in physics, and chemistry have been well documented (Rennie et al., 1999),

a situation that has social justice implications in reproducing inequity since these subjects act as "gate keepers" for entry into vocations involving SET. Research has also indicated that students' classroom experiences are central to their subject choices, not least because these are important influences on females' creations of their own identities (Cotterel, 1996). Body image and peer relationships are at the heart of adolescents' construction of gender identity (Bloustien, 2003), and it has been found that it is "not cool" to do technology related courses (Walker, 2001), other than those associated with, for example, the arts. This disenchantment with technology related study emerges in early adolescence (Norby, 2003). Thus, this study evaluates pedagogic approaches that may make SET study appealing for females in Grades 6 and 7.

Methods

A collaborative participatory action research methodology was adopted for the study (Kemmis and McTaggard, 2000). Judgments about the quality of inquiry were based on the criteria - trustworthiness, authenticity and the benefits of the hermeneutic process (Lincoln and Guba, 2000). The use of multiple data sources maximised the probability that emergent assertions were valid.

Participants

The participants were female students in two Grade 7 classes in a co-educational middle school (School 1), followed by two Grade 6 classes in an all female, denominational school (School 2). Both schools were located in metropolitan Brisbane. All students engaged in a unit of work founded on technology practice, which allowed them to explore key mathematical and scientific ideas. The unit was planned in collaboration with the respective teachers, and a researcher (SJN) taught one 90 minute lesson in each class, each week, for 10 weeks in each school. The findings from phase one of the study conducted in School 1 influenced the pedagogical approach used in School 2.



Data sources

Data sources included interviews, field notes, videotaped observations of students' interactions with objects, peers and teachers, students' planning and construction of artefacts (technology practice), and their explanations of how artefacts worked. Students' perceptions of four dimensions of attitude - investigative nature of the classroom (Investigation); intention to study SET related subjects (Study intention); enjoyment (Enjoyment); and intention to undertake a career in SET fields (Career intention), were assessed using a modified TOSRA (Test of Science-Related Attitudes) survey (Fraser, 1981). TOSRA consists of Likert type questions and has been shown to be a reliable and valid instrument through extensive applications in research (See Appendix A for sample questions from the instrument used).

Analysis

An analytical framework based on Activity theory enabled the researchers to make sense of classroom actions and discourse. Activity theory places people as actors in cultural contexts, shaping and being shaped by the physical environment (Leontyev, 1977). Frequently, models of activity theory show interacting triangles that include the following nodes - subjects, tools, rules, community, divisions of labour and objects. In this study the subjects were the students; the tools were the learning and construction materials; the rules were the implicit and explicit conventions that governed student and teacher activity in the classroom communities. The principal objects were the identities and attitudes the students developed or maintained over the life of the study.

The unit of work

Construction activities formed the basis of the unit and involved students in building powered vehicles of various kinds using *Simple and Powered Mechanisms kits* (Lego Education Division, 2003). The activities were drawn from and engaged the students in the elements of the Technology Practice strand of the Queensland Years 1 to 10 Technology syllabus - investigation, ideation, production, and evaluation of artefacts (Queensland Studies Authority, 2003). The key mathematical and scientific ideas associated with, for example, the use of gears, levers, and pulleys in the powered vehicles, were identified and provision made for investigating these ideas with the students.

The pedagogical approach adopted for teaching the unit in School 1 could be described as "laissez

faire constructionism." The approach involved SJN in the use of rules that focused students' attention during construction activity on explicit and purposeful discussion of the underpinning science and mathematics concepts with the expectation that students were responsible for making their own connections between relevant key ideas. Teachers used time in their own lessons to revise mathematics and science concepts associated with the construction activities.

The pedagogical approach for teaching the unit in School 2 was changed in response to the findings from the first phase of the study in School 1. Firstly, a decision was made to integrate technology practice with mathematics and science by embedding proportional thinking concepts (e.g. rate; ratio; fractions; decimals) in the construction activities, rather than identifying the mathematics and science as an outcome of activities. Lessons designed to cover key prerequisite concepts associated with proportional thinking were planned collaboratively by the researcher and teachers, and taught separately by the teachers. The researcher then emphasised the exploration and use of the embedded mathematics and science concepts in the design, construction, and explanation of the students' artefacts.

Secondly, the pedagogy took into account gender issues that might affect the performance of females in this unit. At the beginning of the unit, fractions and ratios were used to determine if a Barbie model was constructed in similar proportions to the students in both classes. A cardboard cut out of Barbie in profile was constructed using a scale such that Barbie's height was the same as the mean height of all students in each class. Subsequently, the Barbie activity was used as a referent to assist in explaining fraction, scale and ratio concepts in other contexts. The rules for classroom activity could be described as "directed constructivism," in that the rules were specific in scaffolding students to make explicit links between technology practice and underpinning mathematics and science.

Findings

The pretest/posttest scale means for School 1 on the separate attitude dimensions are reported in Table 1. Most students did not have a strong positive affect for learning through technology practice, reflected in mean scores around 3 (undecided/neutral response) prior to the commencement of the unit. A statistically



significant decline in student attitudes for each of the four dimensions can be noted at the end of the unit. While perceived investigative nature of the classroom activity was statistically significant ($p < .05$), the partial eta squared value of .17 (17%) indicated that this effect was not as strong as it was for the other dimensions. An initial, non-committed effect that many students had in relation to the investigative nature of the teaching may have been reinforced, in spite of the fact some students demonstrated knowledge gains in their explanations of their artefacts. The within subject comparison of pre-test and post-test for School 1 was statistically significant ($F=14.10$; $df = 4$, $p < .00$; partial eta squared .72; 72%) indicating that the accumulated result of the four dimensions of TOSRA contributed to an overall negative shift in attitude.

The pretest/posttest scale means for each attitude dimension on TOSRA for School 2 are also shown in Table 1. Similar to School 1, the students in School 2 did not have a strong attitude to learning through technology practice, reflected in mean scores around 3 (undecided/neutral response) for the pretest administration of TOSRA. However, in contrast to School 1, the attitudes of the students in School 2 showed a significant improvement over the second phase of the study, in particular, for the dimensions - investigative nature of the classroom, and enjoyment, as demonstrated by

the high partial eta square statistics. The within subject comparison of pretest and posttest was statistically significant ($F= 14.05$; $df=4$; $p < .00$; partial eta squared .99; 99%) indicating that the accumulated result for the four dimensions of attitude contributed to an overall positive shift in attitude.

Reasons for a decline in student affect in School 1 may be found in the qualitative data. There were four broad areas of concern expressed by those students who demonstrated the greatest decrease in attitude. First, the nature of scaffolding of the learning process, that is, the rules and division of labour between students and the teacher caused difficulties (e.g.):

Cindy: I think you guys should actually get the Lego and go to the front of the class and show us how to build it.

Bev: I have not learnt anything useful and I don't know how to build Lego cars. You never taught us and this annoys me. Doing this makes me dislike science and maths more than I already did.

Second, disenchantment with the links between the activity and construction of knowledge was evident (e.g.):

Anna: In a normal class you might spend a week on one thing, like perimeter, area, circumference and stuff like that.

Dimension	School 1				School 2			
	Mean	SD	N (df=22)	Partial Eta sq	Mean	SD	N (df=35)	Partial Eta sq
Investigation			26	.17			39	.59
Pre-trial	3.85	0.71			3.22	.48		
Post-trial	3.53*	1.08			4.05**	.60		
Study intention			26	.29			39	.23
Pre-trial	3.09	0.80			3.11	.37		
Post-trial	2.65**	0.77			3.42*	.59		
Enjoyment			26	.68			39	.41
Pre-trial	3.26	0.89			2.84	.48		
Post-trial	2.44**	0.97			3.31**	.66		
Career intention			22	.42			39	.35
Pre-trial	2.83	0.76			2.81	.64		
Post-trial	2.19**	0.66			3.23**	.63		

** Significant at $p < 0.01$; * significant at $p < .05$.

Table 1: Pretest and Posttest Results on TOSRA Attitude Dimensions for School 1 and School 2



Andrea: But in this maths it is a bit from everywhere and it is confusing.

Third, the perceived irrelevance of the activities, (e.g.):

Liana: I want to own an equestrian school, and I do not need this stuff.

Sam: I want to be a fashion designer not a technology teacher. You do not need to explain how to build a car.

Finally, a number of students made comments such as, "We could do a presentation." and "We need to be listened to," which indicated that they needed more opportunities for social expression and recognition.

Almost all students in School 2 believed they found the activities relevant and the connection to underpinning proportional thinking was made explicit, (e.g.):

Sam: The really interesting thing is that Barbie looks so perfect as a doll, but when you compare her with us she looks absolutely monstrous.

Georgia: The negative thing was that people who made Barbie didn't make her in the right proportion. If she were a real human she would be as thin as a cat.

The proportionality of Barbie had social connotations for a number of students, (e.g.):

Georgina: I think if Barbie was alive she would be very sad and lonely, because she just would not fit in with any of the others.

Students made comments that could be construed as referring to the rules and use of different teaching tools designed to integrate the mathematics and science with technology practice.

Ruby: I like the way we worked from the blackboard, it was easier to understand.

Brodie: Like now I think mathematics would be more useful, say if you had a bike or something and wanted to work out the gears.

Bronte: I liked working with the ratios and fractions (before) and making sure you've got all the gears working. If you just put it all together like something normal, it would not work.

Paige: I never knew that you needed mathematics for making cars and pulleys. I think you would use mathematics in every job that you might have.

The qualitative results indicate that the many of the students found the activities enjoyable, authentic and interesting. The comments by Ruby and Bronte specifically refer to an appreciation of the form of scaffolding that supported the learning.

Analysis and Discussion

Analysis of student discourse and actions informed us about what tasks, tools, rules, divisions of labour, and community settings, served to assist the female students to construct group and individual identities consistent with the notion that technology practice associated with the hard sciences is compatible with female identity. Importantly, this analysis has enabled us to learn much about the construction of female identity through the students' reactions to the different pedagogical approaches identified as "laissez faire constructionism" in School 1 and "directed constructivism" in School 2.

Student activity in School 1 was dominated by engagement with the Lego tools and the construction of artefacts. The objects or outcomes included disenchantment with the learning process by a number of students. This disenchantment was reflected in more negative attitudes towards the investigative nature of the class activity, enjoyment, study intention, and career intention. The qualitative data indicated that the pedagogical approach was seen as being incompatible with students' scaffolding, social and identity needs.

In contrast, the rules for classroom activity in School 2 were such that student learning was tightly scaffolded. Student activity was directed so that in the classroom division of labour each student was required to make the mathematics explicit. The cognitive tools to do so were provided, accompanied by supportive teaching and the use of models and tools other than those associated with the technology practice. Qualitative data suggest most students embraced this pedagogical approach, which may have been an important factor contributing to the positive changes in attitudes noted in the survey data. It appears that the changes in attitudes of these female students suggest future involvement in SET related activities may be more compatible with their gender identity.



The findings have implications for all SET educators. For example, the findings indicate that female students have specific needs in terms of the types of activities that will spark their interest, consistent with the findings of Gurian and Steven (2004). Analysis of socially significant icons (e.g. Barbie) is recommended, which is in accord with the importance females place on body image (Mazzarella and Percora, 1999). The students wanted to understand the abstractions underpinning construction and they needed specific scaffolding to make the links between the abstraction of mathematics and science and the activity of technology practice. In short, with appropriate rules and divisions of labour and tasks that were related to their intrinsic interests, a number of students in School 2 came to see SET as consistent with their sense of identity.

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Appendix A**Modified TOSRA Instrument**

The test contains a number of statements about the study of science, engineering and technology (SET). You will be asked what you yourself think about these statements. There are no right or wrong answers. Your opinion is what is wanted.

Fill in the column that indicates your response. Record your answer to each statement 1 to 40, by circling the corresponding letter in the relevant column.

- A - Strongly Agree
- B - Agree
- C - Not Sure
- D - Disagree
- E - Strongly Disagree

Sample questions**Dimension: Investigation**

- Q. 1 I would prefer to find out why something happens by doing an investigation than by being told.
- Q. 9 I would prefer to do SET investigations than to read about them.

Dimension: Study Intention

- Q. 2 I would like to study some SET in years 11 and 12.
- Q. 14 I would like to study more SET at school beyond what is compulsory.

Dimension: Enjoyment

- Q. 3 SET lessons are lessons are fun.
- Q. 19 SET is one of the most interesting subjects.

Dimension: Career Intention

- Q. 4 I would dislike having a job using lots of SET after I leave school.
- Q. 16 Working with SET ideas would be an interesting way to earn a living.

Any person who wishes to seek further information about TOSRA (Test of Science Related Attitudes) and the modified instrument used in this study can contact Dr Stephen Norton at the following email address: sj.norton@qut.edu.au

