Preservice teachers teaching technology with robotics

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Abstract
This study investigates the value of a robotics-based school engagement experience for preservice teachers enrolled in a fourth year technology education curriculum unit and analyses their perceived abilities and confidence to design and implement engaging technology activities following this experience. Technology is a key learning area in Australian schools but research shows that most teachers find this subject challenging to teach. This could be attributed to teachers' attitudes and their lack of knowledge, hence investigating preservice teachers' involvement with technology may provide further insights. In this study, 30 preservice teachers used robotics to implement technology activities with 22 primary school students from a school in a low socio-economic area. Surveys were administered to ascertain the preservice teachers' perceptions of their school engagement experiences. The data gathered from the participants showed that they had gained confidence and knowledge from the experience and felt the engagement activity would assist them to develop and implement technology activities in their future classrooms.

Keywords: Technology, teacher education, community engagement, robotics

The Technology KLA

The term technology means different things to different people and this has lead to some confusion regarding the meaning of technology education (Ingerman & Collier-Reed, 2010). Technology is referred to when people are discussing information technology and often it is thought of as this (TEFA, 1998). For example, a 2004 US study by the International Technology Education Association (ITEA), and the Gallup Organization of Princeton, New Jersey, surveyed 800 people and 68% of the respondents identified technology as computers, electronics, and the Internet. However, technology education is more than knowledge about computers and their applications, as these technologies make up only a small part of our technological world.

The draft *Shape of the Australian Curriculum: Technologies* paper (ACARA, 2012) recognises Technology as including the "creative processes that assist people to select and utilise materials, information, systems, tools and equipment to design and realise solutions" (p. 1). The current Queensland technology syllabus (Queensland Studies Authority, 2003) also addresses this broader view of technology as involving the design and production of innovative and creative products and processes to meet human needs and wants. The syllabus outlines the need for students to work technologically and use resources including materials, systems, and information to create products and processes. As a consequence, technological literacy can enable them to "use, manage, assess and understand technology" (ITEA, 2007, p.7).

Technology is now included as part of many education systems requirements for teaching and learning. Australian schools have technology as a Key Learning Area (KLA) with related syllabus and support documents. Yet these alone may not be sufficient for teachers to implement technology as intended, as "the movement from policy to practice is a

complex and unpredictable one" (Brady & Kennedy, 2003, p. 33). The challenges teachers face when implementing the technology KLA includes: intrinsic challenges (e.g., teacher knowledge and confidence in ability to teach technology) and extrinsic challenges (e.g., lack of available resources and professional development opportunities) (Finger & Houguet, 2009).

Although there appears little research about teacher knowledge in primary technology education, McRobbie, Ginns, and Stein (2000) found that primary teachers have limited views on teaching technology. Others (Rohaan, Taconis, & Jochems, 2010) argue that "most primary teachers apparently lack the ability and confidence to develop and stimulate this natural curiosity for technology" (p. 16). Indeed, attitudes and confidence are a possible determinant of teacher knowledge and enhanced knowledge appears related to enhanced confidence (Verloop, Van Driel, & Meijer, 2001). However, teachers' lack of knowledge and confidence may be related to their lack of exposure to appropriate technology experiences in preservice primary teacher education programs (McRobbie et al., 2000). Considering this, activities that foster this enhanced confidence need to be included in preservice education technology units in order to instil positive attitudes and confidence for teaching technology education.

Teachers and preservice teachers need to have a deep understanding of technology subject matter and structure to target students' education in this field. ITEA (2006) lists fundamental concepts as universals of technology, which were categorised into knowledge, processes, and contexts. There is concern that teachers' incorrect conceptual understandings of technology will be transferred to school students (Rohaan et al., 2010). Teachers need to be aware of two key knowledge fields for technology, namely, technological literacy and procedural knowledge, which is a process to solve design problems (Garmire & Pearson, 2006). The goal of technology education is to help students become technologically literate and better problem solvers.

Technology activities are more effective with students when teachers implement activities where students are faced with a task within their proximal zone of development and critical thinking abilities" (Blanchard, Freimana, & Lirrete-Pitrea, 2010). In summary, about establishing effective learning environments, the literature collectively agrees that challenging students in technology education requires teachers to innovatively devise hands-on, problem-solving activities that involve solution seeking.

The Robotics Task

There are many activities that can be devised for learning about technology that foster problem solving and can be integrated with other learning areas. Teaching technology with robotics is becoming increasingly common. Church, Ford, Perova, and Rogers (2010) explained the value of this technology as follows:

> Well designed activities using robotics give students rich opportunities to write about their ideas; utilize mathematical tools and represent their findings via mathematical models; construct 3D artifacts that embody their ideas and solutions; and engage in verbal debate as they work through robotics based design problems and science investigations (p.47).

The advantages of engaging students in robotics tasks to foster technological literacy, problem solving, teamwork and creativity have been reported by numerous studies (Barak & Zodak, 2009; Castledine & Chalmers, 2010; Highfield, 2010; Hussain, Lindh, & Shukur, 2006). Activities such as robotics tasks can challenge students to think about possible solutions. Students can articulate their understandings and reasons why they alter processes to meet the challenges. Barak and Zodak (2009) explain how one group of students who

created a robotic car with assigned challenges "reported that when they tried to prevent their car from slipping on a tangential surface, they thought about skis, on the one hand, and tractor wheels, on the other" (p. 303). This learning engaged students towards understanding key technological concepts.

This study aims to understand preservice teachers' perceptions of designing and implementing a technology lesson where primary school students design, program, and test a robotic car. The design process in this study involved the use of the LEGO NXT Mindstorms robotics kit and sensors and an understanding of how these components can function together as a robotics system (e.g., see also Chan et al., 2007). Seymour Pappert pointed out that there was "a great deal of technology in even the simplest LEGO brick" (Veltman 2001, para 10) and robotics has shown a positive effect on technology motivation in classrooms (Blanchard et al., 2010). This tool has the potential to help build technology literacy and advance higher-order thinking skills such as creativity and problem solving.

In particular, this study investigates the preservice teachers' perceived confidence in their ability to design and implement engaging technology activities following their participation in the teaching experience. Herrington and Oliver (2000) state that "much of the abstract knowledge taught in schools and universities is not retrievable in real-life, problem-solving contexts, because this approach ignores the interdependence of situation and cognition" (p. 23). Immersion of preservice teachers in realistic classroom activities provides opportunities to engage in a range of roles of varying complexities. Working with teachers on specific technology projects can also assist preservice teachers to gain knowledge for pedagogical development (Lave & Wenger, 1991).

Context

Creating positive outcomes for school students, graduating quality teachers, and building aspirations for university in low socio-economic communities are government initiatives that have been at the forefront of Australian reviews (Bradley, 2008; Department of Education, Employment and Workplace Relations [DEEWR], 2010; House of Representatives Standing Committee on Educational and Vocational Training [HRSCEVT], 2007). These initiatives are underpinned by the view that a quality education makes a difference (Hattie, 2003; McArdle, 2010). This study is set in a low socio economic community at a satellite campus of a large university in Queensland. In 2005, a Bachelor of Education (primary) was introduced at the campus. Community engagement was promoted as it was seen as a way to address the issues related to access and equity in a low socio economic context (Williams & Cherednichenko, 2007) and highlight the notion that university can be an option for everyone.

For universities to successfully build aspirations for higher education through community engagement activities, it is essential to have positive relationships with local schools. Kruger, Davies, Eckersley, Newell, and Cherednichenko (2009) note that these relationships need to be underpinned by trust between the partners, mutual benefits to all stakeholders, and reciprocity, where each values what the other partner brings to the relationship. With these core principles in place supporting the partnership, in 2008 the number of community engagement activities increased and culminated in a successful grant application funded by DEEWR known as *Teacher Education Done Differently* (TEDD). It aimed to provide more hands-on activities for preservice teachers advocated by education reviews (e.g. Caldwell & Sutton, 2010; HRSCEVT, 2007) towards assisting them to make the links between the theoretical concepts studied at university and the practice in the field. At the same time participating school students were provided with exciting learning experiences related to a range of curriculum areas and an opportunity to visit the university campus, see what was available, and experience time at a tertiary

institution. These types of experiences are seen as assisting the process of developing aspirations for university as they can help to dissolve negative cultural stereotypes about seeking higher education as a future alternative (Lepkowska, 2011).

As part of the TEDD project thirteen of the thirty two subjects in the Bachelor of Education (primary) were adapted to integrate community engagement experiences. It was originally hoped that more subjects would be included however, time constraints, combined with the appropriateness of some subjects to incorporate such experiences, limited the number. As part of the experiences, preservice teachers participated in a range of curriculum related activities with school students. The majority of the preservice teachers completing the primary degree were from the local community and first in their family to attend university (56% at the time of this study) hence, the preservice teachers were positive role models for the school students who, in some cases, had similar backgrounds. There is evidence (Trice & Knapp, 1992) to suggest that building aspirations for university can be supported by the availability of adult role models with similar backgrounds that can highlight the benefits and possibilities of further education.

As part of the TEDD project the preservice teachers had an opportunity to work with students from a neighbouring primary school on LEGO robotics activities. Preservice teachers aided the students as they built and programmed their robots. On the second and final day the preservice teachers and the primary students were involved in a robotics challenge. Although robotic-based learning was part of the university subject, it was selected as part of the community engagement activities because of the foreseen benefits to the school students. Benefits such as collaboration between students, critical thinking, problem solving, inquiry learning and the development of the language that supports robotics (Blanchard et al., 2010) were viewed as skills that would extend and engage the primary students and promote a positive teaching experience.

Data collection and analysis

Although the community engagement experiences involved preservice teachers and school students, this mixed-method study focuses on data collected from the 30 preservice teachers' (only 21 participated in the final surveys). A five-point (1-5) Likert scale survey and extended response questionnaire aimed to gather the preservice teachers' perceptions of their teaching technology experiences. The survey and questionnaire were administered after the preservice teachers completed the robotics activities with the school students (n = 22) that included 14 year 7 students and 8 year 4 students from a local primary school. SPSS was used to generate descriptive statistics (i.e., percentages, mean scores, and standard deviations). Data sources were triangulated to provide insight into these preservice teachers' experiences.

Results and Discussion

The 21 items on the survey were clustered in four scales – (1) system requirements; (2) teaching practices; (3) technology practice cycle, and (4) attitudes to technology. The items within each scale gave an insight on how the community engagement enriched the pre-teachers experiences. The items in the systems requirements scale gave an indication of preservice teachers understanding of issues that were aligned with the syllabus and teacher standards (Table 1). There appeared to be a discrepancy of alignment between syllabus requirements and implementation for some preservice teachers with 90% claiming they can implement the technology KLA but only 75% agreeing they had knowledge of this syllabus.

Table 1: *System requirements*

Item number and descriptor	%*	*M*	*SD*
13. Implement the technology KLA	90	4.35	0.93
14. Ethical and safety issues	80	4.10	0.97
10. State professional standards for teaching	90	4.45	0.69
11. Knowledge of syllabus	75	4.20	0.95

* Percentage of participants (*n*=21) who agreed or strongly agreed.

From the preservice teachers' perceptions, it appears that the community experience of teaching technology enhanced the knowledge they gained in the *Teaching Primary Design Technology* unit in a real-world context. They felt that could implement the technology KLA. The experience had also heightened their knowledge of ethical and safety issues which are critical in the teaching of this KLA (Gunter, 2007). More importantly, they developed a better understanding of the state professional development standards for teaching and how it linked to this discipline. The items in the teaching practices scale gave an indication of how the experience impacted on their abilities to perform as technology teachers. Eighty-five percent of participants or more agreed that content knowledge, designing and scaffolding activities, questioning strategies, and classroom management techniques were identified critical aspects of effective technology teaching (Table 2). This also provided an indication of their personal technological competency of these preservice teachers. The responses showed a high level of agreement across all items in this scale. The preservice teachers believed that the experience had enriched their knowledge of the technology content. They had not only developed a better understanding of how to design and implement technology activities but they had also become better at scaffolding and managing the activities (Table 2). The community experience had also developed their abilities to ask effective questions in classrooms.

Table 2: *Teaching practices*

Item number and descriptor	%*	*M*	*SD*
15. Content knowledge	90	4.30	0.80
10. Use technology activities in classroom	90	4.45	0.69
21. Design technology activities for all learners	75	4.20	0.95
19. Ask effective questions	95	4.50	0.61
12. Classroom management strategies	95	4.45	0.76
16. Scaffold learning	85	4.35	0.88

* Percentage of participants (*n*=21) who agreed or strongly agreed.

The application of the *technology practice cycle* is critical to the success of technology activities (Queensland Studies Authority, 2003). It is the basis for how well students succeed in the challenges that are presented to them as part of the activities. Most the respondents believed that they could design a challenge within a technology practice cycle (Table 3). Effective design challenges are an essential pre-requisite to successful technology activities and set all the elements of the technology practice cycle in motion. When using robots in activities, investigating (Item 4), designing and programming (Items 3 & 4), testing (Item 5) and evaluating (Item 6) were agreed upon by 80% or more of the participants. High mean scores (*M*) and low standard deviations (*SD*) on items 5, 7, and 8 highlighted that these preservice teachers strongly agreed that the technology teaching experience, built on the foundations of university coursework, helped them to understand how robotics promoted learning (100%) and the technology practice cycle (100%, Table 3).

Table 3: *The technology practice cycle*

Item number and descriptor	%	*M*	*SD*
1. Devise a design challenge	80	4.45	0.83
2. Investigate challenge	95	4.45	0.60
3. Design a robot	80	4.65	0.83
4. Program a robot	95	4.60	0.60
5. Test a robot	100	4.65	0.49
6. Improve a robot's performance	95	4.55	0.60
7. Progress through technology cycle	100	4.60	0.50
8. Learn with robots	100	4.60	0.50

* Percentage of participants (*n*=21) who agreed or strongly agreed.

Teachers' positive attitudes to a subject area are important (Verloop, Van Driel, & Meijer (2001). Without a positive attitude, teachers are unlikely to connect effectively to the content. The responses of the preservice teachers across all items of the attitudes to technology scale showed that the teaching experience had positive impact on them. They felt that the community experience helped them to develop positive attitudes towards teaching technology (100%, Table 4). Observations indicated that it also enabled them to develop strategies to motivate students.

Table 4: *Attitudes to technology*

Item number and descriptor	%	*M*	*SD*
17. Develop positive attitudes towards technology	100	4.60	0.50
18. Motivate students with technology activities	90	4.50	0.69
20. Effectively monitor students' activities with constructive feedback	95	4.60	0.60

* Percentage of participants (*n*=21) who agreed or strongly agreed.

Conclusion

Positive attitudes and confidence for teaching technology education are critical aspects for technology teachers. It is important to include activities that foster this confidence within technology education units to help preservice teachers develop positive attitudes towards teaching technology. This study showed that providing a school engagement experience for preservice teachers impacted on their confidence and perceived abilities to perform as future technology teachers. The robotics activity increased the preservice teachers' confidence and helped them develop positive attitudes towards technology. The preservice teachers indicated that the engagement experience had helped them develop knowledge of how to implement engaging technology activities. The engagement experience also assisted the preservice teachers in developing effective questioning skills and strategies to motivate students. Further research is needed to extend this study to other technology activities and to examine the benefits of the engagement experience for the primary school students involved.

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