SUPPORTING STUDENT LEARNING IN TECHNOLOGY: THE ROLE OF PRACTICING TECHNOLOGISTS

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Abstract

Technology encourages students to resolve problems embedded in real-life contexts through undertaking technological practice. This practice is informed by previous student experiences or those that they have had modelled to them. This paper provides a discussion on the learning environment that supports positive experiences for students when their learning is supported by technologists. It concludes by suggesting how student technological practice, and their overall learning in technology generally, can be enhanced through engagement with technologists. The paper is informed by findings from a research project *Technologists' alongside: impact on student understandings in technology* that was undertaken by the author.

Introduction

Technology education in New Zealand is positioned within sociocultural and constructivist learning theory (Compton and Harwood, 2004). Constructivist cognitive theories acknowledge the importance of prior knowledge to future learning; placing a focus on students' actively constructing understandings and the contextualised nature of learning as the impacts of social, cultural and physical location are realised (Compton and Harwood, 2007). Sociocultural learning theory draws from theories based on situated cognition (Brown, Collins & Duguid, 1989), apprenticeship models of human cognition (Rogoff, 1990), and learning through participation in communities of practice (Lave 1993; Lave & Wenger, 1991). Sociocultural theorists "assume human agency in the process of coming to know" and believe, "that meaning derived from interactions is not exclusively a product of the person acting" (Gipps, 1999, p.21). Rather, influences from the community itself also contribute to the establishment of meaning. As such, these learning theories encourage student learning as supported through interaction with experienced practitioners. This encouragement is reflected in technology in the *New Zealand Curriculum* (Ministry of Education, 2007) where it states that:

> *They (students) also learn about technology as a field of human activity, experiencing and/or exploring historical and contemporary examples of technology from a variety of contexts*
>
> (Ministry of Education, 2007, p.32)

For students to meet the identified aim for technology education and develop a broad *technological literacy* (Ministry of Education 2007), they need to be able to competently undertake and understand *technological practice* within the contemporary technological discourse/s in which they are situated (Compton & Harwood, 2003). Alongside this, they also need to demonstrate understandings of both the *nature of technology* and *technological knowledge* (Ministry of Education, 2007). In saying this however, it is recognized that there are varying degrees of technological literacy that a person may possess. This degree spans from literacy that is *functional* (Barnett, 1994; Custer, 1995; Layton, 1987) to a literacy that is *liberatory* in nature (Burns, 1997; Davies, 1998; Compton, 2001, Compton & Harwood, 2003; Mather, 1994). A person who possesses a *functional literacy* is seen to create technological outcomes through undertaking technological practice and demonstrating understanding of technological knowledge and the nature of technology, from within the boundaries of their current location (Compton, 2004; Compton & France, 2006; Compton & Harwood, 2003). Their outcomes (including their technological practices) most often replicate that which has been done before. A person however, who demonstrates a literacy that is *liberatory* in nature, extends beyond the boundaries of their current location and displays an ability to critique and undertake comparative analysis of past and current technological practices. They also understand technological knowledge and the nature of technology within and across a range of different contexts. Such literacy, allows people to judge the worth of experts (Compton & Jones, 2004) and make informed projections into “potential future practices that step outside and/or push boundaries of their current practices” (Compton & Harwood, 2003, p.4). It is perceived that a person who possesses a liberatory technological literacy can contribute to determining the direction of our future technological society, through their participation as an informed citizen (Compton & Harwood, 2003; Compton & Harwood, 2005). Supporting students to develop a broad technological literacy that is liberatory in nature, therefore, has inherent implications for the sort of pedagogical practice that teachers adopt. As a consequence, the types of learning opportunities students encounter or are presented with, will impact on their overall development towards a literacy that is broad and liberatory in nature.

Two initiatives, *Futureintech* and the *Growth and Innovation Framework – Technology Education Initiative [GIF – TEI]* currently support teachers to deliver and enhance learning opportunities for students in technology, through establishing educational partnerships between technologists and students. Futureintech is an initiative of the *Institution of Professional Engineers New Zealand*. This initiative employs facilitators to assist teachers to establish and maintain industry links with their teaching programmes. An aim of the *GIF – TEI* is to enhance student learning in technology by augmenting teacher practice through business/industry interactions. One identified mechanism for doing this is to encourage the participation of practicing technologists, from the business and the tertiary sectors, in student learning in technology.

To support teaching and learning *indicators of progression* have been developed for the strand components of technology in the *NZC* (Ministry of Education, 2007). These indicators describe at each curriculum level (Levels 1-8) expected student capabilities and understandings, and the learning environment required to support student learning. Many of these indicators identify as important, using examples of technologists practice to support student learning. The Technology achievement standards[1] developed to credential students with qualifications at senior secondary school and registered on the *New Zealand Qualifications Framework*[2] [*NQF*] at Levels 2 in 2005 and Level 3 in 2006[3], and more recently at Level 1 in 2011[4], examine the knowledge students attain from analysing existing technological outcomes and the practice of professional technologists. The scholarship standard[5] for technology also requires students to explore a wide range of technologists practice in order to inform their own undertaking of technological practice. These standards were written in the belief that it is beneficial to have students working with communities of technological practice outside of education, so that authentic contexts that supports student learning in technology are created.

Authentic student learning in technology

The call for student learning to be grounded within authentic contexts is well documented (Brown, Collins & Duguid, 1989; Lave, 1991; Rogoff & Lave, 1984). What constitutes an authentic leaning context, within an educational setting that is "meaningful and useful for students", is however not so clearly defined (Turnbull, 2002, p.27). Brown, et. al (1989, p.6) define authentic learning activities "as the ordinary practices of the culture" and propose that these activities need to provide students with an opportunity to access the perspectives of experts within the community, in order to allow student learning to be meaningful and purposeful. Choi and Hannifan (1995; cited in Altalib, 2002) further suggest that authentic learning cannot be simulated within tasks and activities that are found in educational settings. Rather, to be classified as 'authentic', student learning needs to be embedded in the actual life activities of experts within a community who are engaged in problem solving situations.

1 *Achievement standards* are assessment tools for subjects aligned to New Zealand Curriculum statements (Ministry of Education, 2001; Ministry of Education, 2007). These standards contribute to the award of a *National Certificate in Education* (NCEA) at Level 1, 2 and 3.

2 The *NZQF* is comprised of 10 levels – Level 1 is the least complex and Level 10 the most. Levels 1-3 are standards expected of senior secondary education and basic trades training. Levels 4 - 6 approximate to advanced trades, technical and business qualifications. Levels 7 and above approximate to advanced qualifications of graduate and postgraduate standard.

3 The Level 2 and Level 3 achievement standards currently registered on the *NQF* are written to align with *Technology in the New Zealand Curriculum (Ministry of Education,* 1995).

4 The level 1 2011 achievement standards registered on the *NQF* are written to align with technology in the *NZC* (Ministry of Education, 2007).

5 The *Scholarship standard for technology* is the highest qualification available to students studying technology in general education. It provides recognition and monetary reward to top students in their last year of schooling. Candidates who enter scholarship are expected to demonstrate high-level critical thinking, abstraction and generalisation, and to integrate, synthesise and apply knowledge, skills, understanding and ideas to complex situations.

Dick (1991; cited in Ingram & Jackson, 2005) however, challenges this view of authentic learning and raises concerns about placing students into real world contexts when many of them are not ready for such experiences. He purports that the use of simulations is a better means to present students with learning contexts that are reflective of the real world, than embedding them in actual life activities. Simulations, according to Dick (1991), allow teachers to frame problems based on real world contexts, to ensure that students can engage with them at an educational level. According to Dick (1991) simulations provide an opportunity for teachers to focus student learning on the deeper understandings of concepts. Teachers can also use simulations to emphasise the importance of developing skills that aid the transfer of understandings of concepts to alternative situations and settings (Ingram & Jackson, 2005). Use of simulations assists students to recognise the interconnectedness of concepts rather than concentrating solely on the resolution of a one-off problem or set of problems.

Shaffer and Resnick (1999) suggest that within educational settings there are four identifiable kinds of authentic learning. These include: learning that is meaningful to the student; learning that relates to the world outside of school; learning that provides an opportunity to think in the modes of a particular discipline; and learning where the means of assessment reflect the learning process (Shaffer and Resnick, 1999, p.91). Shaffer and Resnick (1999) also suggest that although each of these authenticities are different, they are "interdependent and mutually–supporting" (p.91) and therefore one cannot be achieved without the other.

Medway (1989) however suggests that authentic student learning only occurs at two levels. The first level, the factual level of authentic learning, occurs when the objects and data students interact with, within the bounds of the learning context, are 'real' in terms of being true to life. At this level of authentic learning, Medway (1989) suggests that even though student learning is bound within the confines of a classroom, the information and tools they interact with can still remain authentic. For example, when the data students are provided to analyse and draw conclusions about, are those currently used (or previously used) by industry and the data processing tools (database) are also industry compliant then learning according to Medway (1989) is authentic. The second level of authentic learning Medway (1989) suggests is focused on the task(s) students are asked to perform, and the degree of authenticity of these tasks. At this level of authenticity, the setting for a project or activity that student learning is centred on is embedded in a 'true-life' context, whilst the task(s) which they are asked to undertake may be engineered to allow for their engagement. Driscoll (2000 – cited Ingram and Jackson, 2005) claims that the focus of authentic learning contexts should be to immerse students in the 'culture of the field' so that they may adopt the role of an apprentice who learns from field experts. Through such immersion, students are able to observe experts, model their practices, and receive coaching on how to replicate them.

For technology in the NZC (Ministry or Education, 2007) to remain true to its sociocultural and constructivist underpinnings, student learning activities need to provide opportunities for students to experience and learn from problems which are both individual and social in nature.

Structuring these activities around authentic contexts that connect to real world settings, capture student interests and offer opportunity to address individuals learning needs is key to ensuring student engagement in technology. Two learning theories, 'apprenticeship model' (Rogoff, 1990) and *Anchored instruction* (The Cognition and Technology Group at Vanderbilt, 1990), offer a means of structuring learning activities and supporting students during the learning process.

The Apprenticeship Model

The key focus of an apprenticeship model is to develop student competence by exposing them to experts who model effective practices and make their tacit knowledge explicit to them (Rogoff, 1990). In this model of learning, as student confidence and abilities increase over time, the modelling and coaching from the expert(s) is gradually withdrawn to the stage where the apprentice eventually becomes the expert. As such, an apprenticeship model of learning aims to enculturate students into authentic practices through activities that engage them in social interactions with experts in the field (Rogoff, 1990). A modified form of Rogoff's apprenticeship model of learning is the cognitive apprenticeship model (Hennessy, 1993). Unlike the apprenticeship model of learning (Rogoff, 1990) that focuses chiefly on developing learner's abilities to perform physical skills, the *cognitive apprenticeship mode*l (Hennessy, 1993) also places emphasis on enhancing the cognitive skills of the learner. Under a cognitive apprenticeship model, student transition from 'apprentice' to 'expert' is centred on their gaining an increased ability to resolve complex and diverse problems combined with an ability to perform physical skills (Hennessy, 1993). The Cognition and Technology Group at Vanderbilt (1990) argue that cognitive apprenticeship is made feasible and is often enhanced when coupled with anchored instruction.

Anchored Instruction

Anchored instruction is an approach to learning which stresses the importance of learning taking place within meaningful, problem-solving contexts (The Cognition and Technology Group at Vanderbilt, 1990). To do this, authentic contexts such as case studies and/or problem situations are used to 'anchor' learning for students, so that not only are they able to solve problems, but also think about the thought processes involved in their resolution. A major goal of anchored instruction is to allow students to make inert knowledge active, through allowing students to "undertake sustained exploration" in order to "understand the kinds of problems and opportunities that experts … encounter and the knowledge that these experts use as tools" (The Cognition and Technology Group at Vanderbilt, 1990, p.3).

Anchored instruction, as a learning or instructional theory, is derived from a belief that when an expert is confronted with a new situation they are able to draw on their prior understandings and experiences, to gain insight into the concepts and principles that underpin it. This ability of an expert to identify the relevance of previously learnt understandings to new situations is thought to be due to their being “immersed in phenomena” and being “familiar with how they have been thinking about them” (The Cognition and Technology Group at Vanderbilt, 1990, p.3). Experts, when introduced to new theories, concepts and/or practices that have relevance to their own area of expertise, are therefore able to make reasoned changes to their own thinking that takes account of these new ideas. When a novice (student) however, is confronted with new theories concepts and/or practices, they often see these as merely “new facts or mechanical procedures that need to be memorised” (The Cognition and Technology Group at Vanderbilt, 1990, p.3). This is due to their limited experience in being immersed in phenomena that is under investigation, which results in an inability for them to notice and make meaning of new information.

Applying an anchored instruction pedagogical approach alone within education, particularly with younger inexperienced students in technology, therefore may not encourage students to develop a technological literacy that is liberatory in nature. When an anchored instruction approach however is coupled with *cognitive apprenticeship*, an opportunity to overtly place importance on how and why experts use specific skills and knowledge in their practice is created. Using this combined approach in the delivery of technology education, offers an opportunity for students to inform their own practice using insights gained, working alongside technologists, and/or through analysing their practices. It also assists in avoiding students’ educational learning outcomes being solely the replication of those created by experts. Such an approach provides opportunity for students to develop conceptual understandings that span across learning contexts or situations.

Supporting student interactions with technologists

Findings in research conducted by Harwood (2007) showed that the nature of the interaction between students and a technologist(s) influenced the specific understandings that the student developed and practices they later adopted, including their overall development of generic understandings. Where student/technologist interactions were focused solely on resolving a technical problem related to the students practice, for example resolving a specific problem encountered by the student, the research showed that student responses commonly mimicked the practice and/or solution provided by the technologist. In these instances the critical analysis of a technologist(s) technological practice used to resolve a similar problem to that encountered by the student was not prioritised. As such, it appeared where this situation occurred that an expert - apprentice relationship, or apprenticeship model (Rogoff, 1990), had been established between the technologist(s) and student(s), and that the ownership of the problem and hence its resolution belonged to the technologist(s). The problems solution therefore was one that the technologist(s) had previously applied or developed in response to a similar (or the same) problem. Student critique of the technologists’ practice to identify how they resolved problems similar to the one they had encountered was not apparent in students' practice that followed a strict *apprenticeship model* of student/technologist interaction.

Where teachers however presented their students with meaningful problem-solving contexts, and prepared their students and technologist(s) to work alongside one another, so that they possessed a shared understanding of the purpose of why they were being asked to interact with one another, then the resultant learning for students (and technologist) were different to that described above. In these instances the resulting relationship established between students and the technologist(s) were more akin to *cognitive apprenticeship* (Hennessy, 1993) and *anchored instruction* (The Cognition and Technology Group at Vanderbilt, 1990) models of learning, rather than an *apprenticeship model* (Rogoff, 1990). In this instance the technologist was fully aware of the role they were playing in a students' overall learning in technology, and the importance of students developing an understanding of the thought processes they used to resolve problems and/or undertake technological practice. As a result technologists were able to ensure that their relationship with students required the student to ask questions about 'why' they did things the way they did, without an expectation that their expert practice would or should be simply mimicked by students.

This research (Harwood, 2007) also showed that when teachers adopted *cognitive apprenticeship* (Hennessy, 1993) and *anchored instruction* (The Cognition and Technology Group at Vanderbilt, 1990) models of learning, and used case studies and/or activities to support students to develop frameworks and skills to critically analyse the practices technologists used when resolving problems, students were better able to uncover the thought processes (or tacit knowledge) technologists applied when solving problems. This was due to students being equipped and confident in their ability to question how and why technologists used specific skills and knowledge the way they did, to develop their technological outcomes. This approach to learning also supported students to subsequently transfer their developed understandings to problem situations and settings that they later engaged in.

Where the context of student learning activities were similar but not the same as the context of a technologists' practice, the research findings (Harwood, 2007) showed that students were more likely to assess the worth of any understandings they gained from the technologist and use these understandings to inform their own future practice. In contrast, where students worked alongside technologists in the same context to resolve a common problem, this sometimes led to students deferring to the expertise of the technologist and adopting their practices without critiquing it on its merits or appropriateness. Whilst the former situation (working alongside technologists in contexts similar to, but not the same as the students) was seen to aid students' development of a technological literacy that was liberatory in nature, the latter (working alongside technologists in the same context) was seen to be a limiting factor, as it tended to lead students towards developing a technological literacy that was more functional in nature.

Conclusion

From the research findings there appeared to be an apparent benefit, if student learning in technology is grounded in a cognitive apprenticeship (Hennessy, 1993) and anchored instruction (The Cognition and Technology Group at Vanderbilt, 1990) models of learning. Underpinning student learning in these models of learning, assists teachers in presenting authentic real-life problem contexts to students and encourages them to draw understandings from the practices and outcomes of technologists through critical analysis. Where problem contexts encountered by technologists may be similar to those that students are required to explore in their own technological practice, they need not necessarily be the same.

Where teachers provide space within their technology programmes to allow students opportunity to interact with technologists, there is a need to establish solid foundations upon which these interactions occur. Such foundations include:

- establishing a shared understanding by both the students and technologists of why they are being asked to interact with one another
- ensuring students have the critical skills to interact with, and critique the practices and outcomes of the technologist
- informing technologists about the educational learning that the teacher hopes the student will gain as a result of their interacting with them
- assisting technologists to understand the overall aim of and philosophy underpinning technology education, and how this differs from the subjects they may have studied themselves at school[6].

The research (Harwood, 2007) did not specifically investigate if when students worked alongside technologists, their understandings about components of the *technological knowledge* and *nature of technology* strands, (Ministry of Education, 2007) were enhanced. In saying this however, these two strands encourage students to analyse and critique the perspectives of others, outside of their current location, so that they may develop understandings *of* and *about* technology that contributes to their developing an overall technological literacy that is *broad, deep and critical* in nature (Compton & France, 2006). Encouraging students to work alongside technologists in activities grounded in authentic real life contexts that are underpinned by *cognitive apprenticeship* (Hennessy, 1993) and *anchored instruction* (The Cognition and Technology Group at Vanderbilt, 1990) models of learning may well assist them to gain an appreciation of things such as:

[6] For the majority of current practicing technologists involved in the research (Harwood, 2007) their experience in studying technology related subjects at senior secondary school is founded on earlier workshop and design based technical curricula

- the ways in which individual and group beliefs, values, and ethics can constrain or encourage technological development
- the way things work individually and together in the development and overall function and acceptance of a technological outcome
- the ethics, legal requirements, protocols that need to be considered and/or adhered to in developing and using technological outcomes
- the needs of and impacts on potential stakeholders due to the development of a technological outcome, including the site where it is developed and finally located
- the characteristics of technological knowledge
- how knowledge is integrated and transformed in the course of technological development
- the social, technical, and environmental impacts of historical and contemporary technological developments.

The findings of the research (Harwood, 2007) support the continuance of initiatives such as *Futureintech* and *Growth and Innovation Framework – Technology Education Initiative* that promote the establishment of co-operative relationships between industry and education communities. It also validates the focus of NCEA and Scholarship technology assessments, which encourage students to develop their understandings and technological practice as a result of exploring and interacting with technologists.

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