Pre-service Teachers' Conclusive Principles for Teaching Technology Education

Paul Snape, University of Canterbury, New Zealand

Abstract

What enduring knowledge and understanding from tertiary education study will learners remember most that will contribute to their on-going performance and understanding for effective teaching? This paper is based on research undertaken to identify what third-year initial teacher education students in a course including Technology Education curriculum development conclude as important principles for teaching that discipline effectively in their classrooms. Their course-concluding principles should be seen as first steps or thoughts as they transition from university into their first appointments and begin teaching. Literature on personal epistemologies (Brownlee, Schraw & Berthelsen, 2011) identifies that pre-service teachers' awareness will also be reflective of prior experiences they have had in the community and from teachers they have been exposed to and that their naïve epistemologies will give way to more sophisticated beliefs and practices as their confidence and understanding develops. The students' conclusive principles were analysed to identify the nature of their understanding and as a guide to what teaching in this discipline might look like as they begin their teaching career.

Key words

initial teacher education, technology education, conclusive principles, personal epistemology, pedagogy, design and technology, D&T

Introduction

Initial Teacher Education programmes will endeavour to help students extend their personal epistemologies (Brownlee, Schraw, and Berthelsen, 2011) in preparation for them entering the teaching profession. While a good amount of this will already be established by their prior experiences at home and in schools (Bhargava, 2011 & Yadav, Herron & Samarapungavan, 2011), along with any contextual and conceptual connections to discipline areas, academics would expect to be able to influence their knowledge through course content and practice. Teachers' personal epistemologies will outline the beliefs they develop about the nature of knowledge and knowing, and it is this that will strongly influence what they will teach, how they will teach it and how they will learn to do this

(Schommer-Aikens, 2004; Hofer, 2010). Thomas (2013) cites Uztosum and Calderhead who conclude that there are five areas of teacher's beliefs including: learners and learning, the subject, teaching, learning to teach, and beliefs about self and the teaching role. This article investigates what students in an initial teacher education course identify as being most important for their developing understanding of classroom teaching in Technology Education.

In New Zealand universities undergraduates in initial teacher education programmes complete a three-year degree. In the qualification in which this research was undertaken they complete one curriculum course in Technology Education in a paper that is shared equally with Science Education. Part of one of the course assessment asks the students to establish a number of conclusive principles confirmed from their understanding of the course content that will be significant to their teaching of Technology Education once they graduate and become classroom teachers. The research reported in this article identifies the conclusive principles they have embraced to date and consider most to be important. The article will rank these by importance and describe how they are perceived by students once they have completed the course.

Background, assessment and methodology

Technology Education is one of eight disciplines in the New Zealand Curriculum, 2007 (Ministry of Education, 2007a). In New Zealand Technology Education is a compulsory learning area until Year 10 of schooling (about 15 years of age) and it can then be taken to a higher level in the final three years of secondary schooling. Credits achieved in these final three years of secondary schooling are accepted as accreditation for university entrance. For the first six years in schools children will be exposed to Technology Education in programmes generally run by the classroom teacher. From Year 7 students attend classes taught by a range of specialist technology teachers covering food and biotechnology, digital, information and communication technology, resistant materials and other process and manufacturing technologies.

The Technology Education curriculum consists of three key strands: Nature of Technology, Technological Practice, and

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Technological Knowledge (Ministry of Education, 2007a). In the primary school this learning area is usually presented in a holistic way with learning contexts developing understanding and skills from all three strands. An emphasis on Technological Practice effectively requires an integration of the other two strands as well as it is essential students have the knowledge required and that their outcomes are authentic and respond to their client's needs. The Nature of Technology strand develops awareness of the bigger picture purposes and drivers of technological development, and an understanding of the characteristics of technological outcomes and the design elements which define them. From the Technological Knowledge strand children experience learning opportunities in technological modelling and an understanding of the nature of products and systems.

Teachers have access to an online web portal (http://technology.tki.org.nz/) which provides further details of the key teacher knowledge required, along with teaching resources and thousands of examples of student work and industry case studies. Teachers are also well supported by a national professional subject association, Technology Education New Zealand (TENZ) which provides professional development opportunities, an informative publication called 't-news' and a biennial conference which also attracts a number of international academics and teachers.

At the institution where the research was carried out, Science and Technology Education: Nature and Practice is the course completed by students undertaking the Bachelor of Teaching and Learning degree in Primary Teacher Education as part of their three-year undergraduate initial teacher education qualification and is taken in the first semester of their final year of study. Most curriculum learning for these students is introduced in courses with pairs of learning areas, e.g. Health and Physical Education, Visual Art and Music, Social Science and Learning Languages, and Science and Technology Education. English and Mathematics courses are taken each year, initially separate and then in combined courses. Each course is completed within a half-year semester with 36 – 48 hours of contact with staff in both lecture and smaller group workshop sessions. There is an expectation that each course requires 120 -150 hours of student work throughout the semester.

For the Technology part of the course students attend seven one-hour lectures, complete four two-hour practical workshops and one three-hour laboratory. The course is aimed at developing an understanding of the nature and content of Science Education, Technology Education, and the interrelationship between these two disciplines. The workshops and laboratory session involve a high degree of practical work that incorporates an authentic, collaborative and integrated inquiry approach to developing technological literacy. They explore contexts of study for the classroom with lecturers role-modelling exemplary classroom practice and techniques. By this stage in the three year programme students will have already completed 19 weeks of professional placements in schools, and courses in curriculum, education and professional inquiry. Most students are beginning to develop a sound philosophy and pedagogy for teaching which will influence their on-going study and become the first steps in their professional learning journeys (Choy, Chong, Wong & Wong, 2011, p. 84-85).

This new course was developed in 2013 as part of a restructure of an existing Bachelor of Teaching and Learning degree and saw for the first time the connection of these two disciplines in the same paper. It was designed using the Pre-service Technology Teacher Education Resource (PTTER) (Forret, M., Fox-Turnbull, W., Granshaw, B., Harwood, C., Miller, A., O'Sullivan, G., & Patterson, M., 2013, p. 473-487), a framework collaboratively developed as a cross-institutional resource by academics of six of the universities in New Zealand. The framework is aimed at providing a tool to enhance and encourage consistent practice and teaching within schools in New Zealand and can be accessed from the Ministry of Education's web portal (http://technology.tki.org.nz/Teacher-education/Pre-service-technology-education-framework). Early discussions in the planning for the course identified that while the framework had been developed by the Technology fraternity its principles were true for most curriculum disciplines, including Science, and that is was ideal for use in the development of this new course. This framework outlines four critical elements essential for consideration by teacher educators and future teachers, identifying that they will require an understanding of the philosophy, rationale, curriculum content, and what it takes to teach it to today's students. While this framework is presented below in a Technology Education context, educationalists would quickly identify that it would be a suitable framework for any school-based learning discipline.

The four elements identified in the PTTER framework considered to be foundational to technology teacher education programmes are:

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Philosophy of Technology: establishes a philosophical foundation for technology as a field of human endeavour. This element enables student teachers to develop a robust personal construct of technology

Rationale for Technology Education: provides the opportunity to critique and argue for the place of technology in education. This element allows student teachers to understand why technology education should be taught

Technology in The New Zealand Curriculum: acknowledges the place of technology in The New Zealand Curriculum. This element enables student teachers to understand the aims and intention of technology in The New Zealand Curriculum

Teaching Technology: provides an insight on how to implement technology education in New Zealand classrooms. This element prepares student teachers to teach technology.

Source: Ministry of Education, retrieved from http://technology.tki.org.nz/Teacher-education/Pre-service-technology-education-framework/Element-overview on 24 Aug. 2015

Supporting the framework is a wealth of resources that provide a pool of material to assist teacher understandings of technology education across the various sectors of schooling (Forret et.al., 2013, p. 476).

Within the Technology component of the course students are introduced to and engage in the philosophical underpinnings of technology. Technology is portrayed as value-laden, socially embedded, and both influencing and being influenced by society. Mitcham's conceptualisation of technology (Mitcham, 1994 cited in de Vries, 2005) which sees technology as: objects, knowledge, actions and volition, is presented as the philosophical underpinning for this learning discipline.

The main assessment task for the course is a reflective journal collating six tasks based on their own Technology and Science practice and their personal constructs of these learning areas. The first of these tasks completed after the third week, is the development of a personal construct and a consideration of the curriculum and societal challenges for each of the disciplines. Students will use key readings and course content to unpack the philosophy (de Vries, 2005) and rationale (Ministry of Education, 2007a) elements relating to the nature of the

Science and Technology Education learning areas. Once this foundation has been established in the course the students are then introduced to the curriculum components, discipline content and the pedagogical implementation strategies most effective for teaching and learning in schools. This content is presented in lecture and practical workshop sessions and is supported by modelling of exemplary classroom practice and teaching techniques.

Once the students have a complete understanding of the four PTTER elements they are in a position to generate the final reflection task requiring them to identify six conclusive principles from the course content that will influence their teaching of these learning areas as they begin their teaching career. They present two for Technology, two for Science and two that are integrative and would promote learning for both. Each conclusive principle needed to be introduced and described in less than 250 words and to be supported with references to course materials. Over time as they teach in these areas, attend further professional development and gain in experience and confidence their assumptions will most likely change and evolve in different directions.

Data from eighty-eight students' assessments identifying the most significant Technology and integrative conclusive principles was gathered and collated from their assessment presentations submitted two weeks before the course ended. A deeper analysis has been completed of the conclusive principles that were advocated by more than twenty percent of the cohort.

Research questions

The purpose of the paper is to examine the significant conclusions of students completing the course and how these relate to an understanding of Technology Education teaching and pedagogy in the classroom. The findings will help confirm to those teaching the course whether it is developing the intended philosophical and practice expectations. This study then seeks to answer the following questions:

1. What significant conclusions about Technology Education teaching do students draw from the course?

2. How do they relate these ideas to their understanding of teaching Technology Education in the classroom?

3. Why do the particular principles effectively promote good learning in Technology Education programmes of work?

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Science and Technology Education

Guiding Principles: Student perceptions (>10%)

Number of Students = 88

Conclusive Principle	Number	Percentage
Authenticity	68	77%
Collaboration	31	35%
Inquiry Learning	24	27%
Integration	23	26%
Technological Literacy	21	24%
Design Process	20	23%
Teacher Knowledge	18	20%

(Others <20% included: assessment, bi-culturalism, hands-on, constructivism, questioning, metacognition, life-long learning, problem solving, rich resources, classroom environment, knowledge development, ICT, portfolios, and teacher planning)

Table 1. Indicating the number and percentage of students selecting a particular conclusive principle.

Findings

Conclusive principles identified by the students covered a wide range of possibilities including pedagogy, content knowledge and educational technology integration expected of teachers today (Shulman, 1986; Koehler & Mishra, 2009). The top four principles all focussed on the pedagogical connections considered important in how Technology Education is best presented to learners. By far the most common was that of authenticity (Turnbull, 2002; Splitter, 2009; Snape & Fox-Turnbull, 2013) identified by 77% of the students and followed by collaboration, inquiry and integration. The next five were significantly content-based involving technological literacy, design process, teacher knowledge, assessment and bi-cultural perspective.

Discussion

Authenticity 77%. Students identifying with this principle identified the importance of learning in technology being meaningful and relating to real-world contexts if children were to be engaged and excited in their learning. Student 7 stated that, "presenting activities connected to the children's experience makes the transition between their world view and school learning easier" (Fleer, Hardy & Jane, 2007). Other students noted that the technological practice they would encourage would be that used by technologists in the real world. It is about motivating

children to learn by providing connections to help them understand what happens in the real-world. Student 18 identified that it was important for children to become familiar with a range of communities and environments of practice. Authentic learning requires authentic teachers providing students with opportunities to understand their world and take greater responsibility using intrinsic and conative motivation (Riggs & Gholar,2008). Authentic practice will foster learning, empower students, encourage responsibility and self-management, and help develop transferrable skills, attitudes and dispositions (Claxton, 2007) required for them to become robust citizens in C21 century society. Student 86 surmised that motivated and engaged students are less likely to present behavioural management issues and that it was very important for children to see purpose and reality in what they were learning.

The course introduces authenticity to the students particularly through the use practical workshops where meaningful contexts with connections to everyday life in the real world. The students are also exposed to authentic practices and processes utilised by technologists in their work. Each student's individual technological practice demonstrated through their portfolio is focussed on a real need from an actual client. The task required students to develop a textile toy as a technological outcome for their

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client, who on completion fully evaluated its suitability. Students were required to ask their client to complete an authentication sheet to evidence the integrity of the project, with a number of these being verified by lecturers.

Collaboration 35%. This second most commonly identified principle is closely related to authenticity in that in the real-world much technological practice is frequently completed in collaborative environments. These will range from teams working within the same company to collaboration in global and multi-corporate contexts. Participation and Contribution, and Relating to Others are two of the five Key Competencies from the New Zealand Curriculum that people use to live, learn, work and contribute as active members of their communities (Ministry of Education, 2007b). The five Key Competencies are generally developed through integrative approaches in everyday programmes of work in the classroom. Explicit teaching of Key Competencies occurs within meaningful and authentic practice. Technological practice will provide powerful opportunities for children to experience, learn, and gain confidence from these interactions with others. Student 9 considers collaboration as students working together, working with people in the community, and creating technological outcomes for clients. Student 10 identifies the discourse arising from collaboration as important for correcting misconceptions, expanding understanding, and bouncing potential ideas for their practice. Students 19, 24 and 43 particularly identified the advantage that community engagement through learning outside of the classroom visits or bringing visitors in to the classroom as experts or mentors as an essential part of their personal epistemology for effective teaching and learning. Collaboration with stakeholders and clients was also seen by many as helpful in developing motivation and also bringing a high degree of accountability to the children's engagement and performances.

During the course students were introduced to a number of practical tasks that involved and modelled collaborative practice. One of these workshops investigated how modification of outcomes exists in technology and incorporated an investigation of functional modelling processes. The activity focussed on an enquiry into the nature of potato peelers and how they have been modified in different ways over time. Working in groups of six, initially the students worked in three pairs to analyse a given peeler. They used the peeler to peel a potato to ensure they understood fully how it worked and they then sketched it with annotations indicating the function of the various aspects of the peeler. Following this they considered on-going potential modifications for a 'new

age' peeler. Each pair then explained its existing peeler using their annotated sketch and introduced their new design ideas. As a group they decided on an idea for a new peeler and then diversified their labour to complete the task. One pair produced a mock-up of the peeler using a range of recycled and construction materials, a second pair used the sketches, new designs and conceptual design for the new peeler to create a paper-based presentation, while the third pair developed a promotional campaign for the new peeler using a TV shopping style, many including the obligatory free set of steak knives. This activity highlighted many different aspects of authentic collaboration.

Inquiry learning 27%. Technological design process models (Fasciato, 2002) often reflect typical inquiry learning processes (Kuhlthau, Maniotes & Caspari, 2007) and this pedagogical approach supports current socio-constructivist theories of learning supported by Lave, Bruner and Vygotsky. Inquiry learning supports students taking greater responsibility and management for their learning. Typically a guided inquiry learning (Kuhlthau et. al.) approach will involve immersion and initiating, selection of focus, research and exploration, formulation of ideas, collection and presentation of findings, and finally assessment. Guided Inquiry offers children an opportunity to build on what they already know and gain new knowledge through active engagement in and reflecting on an experience and learning. Children are able to develop and use higher-order thinking skills with teacher guidance at critical points in the learning and development process. Student 25 states, "In Technology this means that students have an ownership over their own development of a technological outcome and the teacher scaffolds the process and content of the learning." Technological practice requires dialogue with stakeholders and clients and where students are free to design their own solutions inquiry is a natural requirement to obtaining the information needed and then utilising it to develop an appropriate result. Student 32 identifies how it empowers students to take ownership and provides opportunities to engage with others developing higher-order thinking through their discussions.

Students were able to use their understanding of the inquiry process and see its connection to the technological process as they engaged in their required individual technological practice involving an authentic client. Students needed regular contact with their client to ensure decision-making was appropriate. They had control over the way they worked and the directions they took. Their practice resulted in a confirmation of the similarity of the inquiry and technological processes.

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Integration 26%. The multi-disciplinary nature of Technology Practice and the embeddedness of societal perspective make Technology an ideal vehicle to promote integrated curriculum (Murdoch & Hornsby, 2003). As children work through their technological practice they will engage in aspects of English literacy, mathematics, science, art, health, social sciences and more. Developing this learning within an authentic context and in a way that combines learning from a number of disciplines will provide purpose and meaning for their understanding and help demonstrate the way curriculum is interconnected. Some might see Technology as the application of Science and certainly many technological outcomes utilise the knowledge, understanding and concepts developed through from the world of Science. Student 79 concludes with, "Technology in our built world depends on Science for its future."

There was a requirement in this assessment that as part of their individual practice portfolio they must complete a scientific investigation to help clarify, explain, and inform their technological practice. This meant exploring the nature of textiles to understand suitability, appropriateness, best choices, safety and reliability. The peeler workshop undertaken earlier in the course was also an example of how technological practice incorporates skills and understanding from a number of different learning areas. This included the use of drawing skills and techniques, measurement, writing, drama, oral communication and presentation, bi-culturalism, etc. Bi-cultural perspectives in New Zealand are those that inform and respect the special relationship between the Māori and European (Pākehā) people. Māori traditionally hold food resources in high esteem and therefore do not waste them so in the peeler exercise the peeled potatoes are chipped, coated with herbs and spices and then cooked as a snack for students when they leave the workshop. The practical workshops also act to provide opportunities for teaching and experiencing a range of 'soft skills' and dispositions like problem solving, critical reflection, evaluation, metacognition, group cooperation, participation, self-management, etc.

Technological Literacy 24%. The three strands of the Technology Curriculum: Technological Practice, Technological Knowledge, and the Nature of Technology contribute to the 'whole' of technological literacy (Compton & France, 2007). The holistic nature of technology curriculum means that children's practice and learning will invariably connect with achievement objectives from all three strands. The children's Technological Practice relies on aspects of Technological Knowledge and modelling to better inform their decisions

and will be strongly influenced by the Nature of Technology itself. Primary school technology will generally result in technological practice so it is essential that they develop understanding of all three strands in the work they do. As they undertake their own technological practice to meet needs or opportunities they will understand how technology intervenes in the world and how developments are influenced by historical, social and cultural factors. Seemann (2009) identifies that Technacy is proposed as a third essential pillar for new learning alongside literacy and numeracy. Technological outcomes filter into all aspects of everyday lives and are significantly influenced by the needs and considerations of widely diverse groups. As such Seemann asserts that technacy education is a holistic approach to perceiving, teaching, practicing and learning technology in any culture. It seeks " …to develop skilled, holistic thinkers and doers who can select, evaluate, transform, and use appropriate technologies that are responsive to local contexts and human needs" (Seemann, 2000, p.2).

The course introduces students to the learning direction of the Technology curriculum. They identify learning in this area as being different from other curriculum areas in that programmes of work will invariably incorporate learning from all three strands and most of the achievement objectives that make up the Technology curriculum. In other learning areas learning mostly focuses on developing a smaller number of achievement objective and these may be quite disparate. As technological contexts are explored students are encouraged to see the links to the different achievement objectives and how they are intertwined. To develop a technological outcome students will need to understand aspects of the Nature of Technology (Achievement Objectives: Characteristics of Technology and Characteristics of Technological Outcomes), Technological Practice (Achievement Objectives: Brief Development, Planning for Practice and Outcome Development and Evaluation) and Technological Knowledge (Achievement Objectives: Technological Products, Technological Systems and Technological Modelling). Understanding the nature of this learning and how each is involved in the technological process is essential.

Design Process 23%. Student 10 sees that a range of design processes should be introduced to children as they create, carry out testing, and develop briefs, designs, mock-ups, models, and plans. Student 31 identifies a model developed by Kimbell, Stables, Wheeler, Wosniak and Kelly (1991) as a good guide for children completing technological practice, whereby practice is an interactive 'tennis match' of work in the head (reflective) and in the

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hand (practical) work. Design process was seen by most students from a micro perspective of the technology process focussing particularly on the inquiry and practice aspects with significant links to creativity and problem solving (Fasciato, 2002). Student 86 considers it extremely important for children to be scaffolded through the design process to ensure they are able to transfer an understanding of the process to future projects.

The Reflective – Active design process (Kimbell et. al, 1991) is used as an example in the course that links very clearly to the Brief Development and Outcome Development and Evaluation achievement objectives of the Technological Practice strand of the curriculum. Students use this model as a guide for their practice in completing the required textile toy development. It clearly focuses them on the required thinking and actions needed throughout the stages of design.

Teacher Knowledge 20%. A good understanding can produce insight into how to construct appropriate teaching and learning situations (de Vries, 2005). Once the intended learning has been identified it is critical for teachers to then research to unpack what that learning involves in order to determine the teaching points that will be required in lessons. Most of the seventeen students, who chose this aspect as a conclusive principle saw that this was important for their confidence, planning, trouble shooting and effective teaching. Student 16 appreciated the need for teachers to be continually addressing their knowledge by taking advantage of professional development opportunities but also acknowledged that teacher knowledge can be developed alongside the children as they worked together. Student 38 considered domain knowledge to be critical noting that procedural, conceptual, societal and technical knowledge (Jones & Moreland, 2001) was essential with the first and last of these having a strong influence on an awareness of the health and safety considerations for technological practice. Teacher knowledge will include that of the content required for teaching and also the understanding of how to most effectively teach it. This is often presented as pedagogical content knowledge (Koehler & Mishra, 2009).

The course introduces teacher knowledge as one of the critical challenges for teachers and for successful and effective learning in the classroom. Knowledge helps bring confidence and it is often a lack of teacher knowledge in Science and Technology that is a key factor in poor teaching or an avoidance of these learning areas in classroom programmes. Professional Inquiry courses in the Bachelor of Teaching and Learning degree emphasise the importance of identifying the critical knowledge

needed for learning to be successful. Students understand how clear learning intentions (Clarke, Hattie & Timperley, 2003) will identify what is to be taught and that identifying the knowledge relevant to this learning is required before deliberate acts of teaching or instructional strategies can be selected to complete the learning sequences.

Limitations

With two years of teacher education learning behind them students bring a partly developed knowledge and understanding of effective teaching and learning to the course. Learning from other courses and their professional practices in schools will already have influenced their thinking, and ideas presented in 18 hours of Technology Education, in a course combined with Science Education, may not have had a significant impact. Technology Education is a particularly multidisciplinary learning area meaning there will be many contextual learning links to practices and content from courses already completed. The question of whether aspects of Technology, Science or another learning area contributed mostly to each student's understanding was not fully investigated. Next steps research could investigate these factors further and be followed up with observation of some of these students teaching Technology Education in classrooms inthe following year. Such research could confirm that the Science and Technology Education course has contributed to their pedagogical understanding and that their teaching skills have been influenced by the approach taken by lecturers in the course.

Conclusion

The students have acquired a strong set of principles which are highly supportive of current socio-constructivist teaching and learning theory and connect well to appropriate ways to introduce Technology and Technological Practice to children in school. With the four most commonly used principles having a more pedagogical influence to them it is likely that their personal epistemologies have been strongly influenced by their previous experiences in professional practice or professional inquiry courses. However the pedagogical strategies selected are indeed very conducive to the teaching of Technology Education and are in fact practices modelled and utilised by lecturers in the course. The more generalist nature of their significant conclusive principles may suggest a more naïve personal epistemology (Yadav et. al, 2011) stemming from a less confident or still inexperienced understanding of the nature of Technology Education. They did, however, as recorded in the findings justify many of these strategies by linking them to appropriate Technology pedagogical

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knowledge and content. As an initial step into the nature of this curriculum the students have successfully identified very positive ways to present Technology Education to children in the classroom. Their specific curriculum content knowledge will expand with more experience and on-going professional development. They have identified and defended conclusive principles that would promote effective learning in technology Education.

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