

Designing for explicit TPACK development: Evolution of a preservice design and technology course

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Abstract: The Australian Government has funded the *Teaching Teachers for the Future* (TTF) project across all teacher preparation programs with the intention of enhancing the capabilities of graduate teachers for integrating Information and Communication Technology (ICT) in their classrooms. Although the project has focused on the first four subjects of the national curriculum (English, Mathematics, Science, and History) it is expected that the changes made in those areas will spread across teacher preparation programs. This paper describes the evolution and revision of a subject within a teacher preparation program to reflect the TTF focus on developing graduates' Technological Pedagogical Content Knowledge.

Introduction

The Digital Education Revolution (DER) is the name given to the Australian Government initiative intended to achieve a national vision for realizing the potential of Information and Communication Technology (ICT) in school education (DEEWR, 2008). That vision included ensuring both that students left school with knowledge and skills required to apply ICT in their careers and that ICT would be used to enhance learning and teaching across the curriculum. A large part of the funding allocated to the DER was to increase the provision of computers to reach a ratio of 1:1 for years 9 to 12 by 2011 but the implementation roadmap also recognized that “educators require the pedagogical knowledge, confidence, skills, resources, and support to creatively and effectively use online tools and systems to engage students” (AICTEC, 2009, p. 6). In 2010 applications were invited for funding of projects to improve the capabilities of preservice and inservice teachers for working with ICT (DEEWR, 2010).

A single national project supported by all thirty-nine higher education institutions offering teacher preparation was successful in attracting the funding allocated for the preservice teacher education sector. The major component of the *Teaching Teachers for the Future* (TTF) project provided funding to each institution to employ the equivalent of one additional person with expertise in classroom integration of ICT (an ICT Pedagogy Officer – ICTPO) for a year and to release a senior faculty member half-time in each institution to manage the project. The role of the ICTPO is to work with teacher educators and their classes in one or two of the curriculum areas (English, Mathematics, Science, and History) for which the new national curriculum is being implemented to audit current practice and explore ways to enhance it. The intention of TTF is that successful practices would be shared among institutions through a national support network and that all aspects of teacher preparation programs would adopt practices to enhance graduates' capability for working with ICT. The TTF proposal identified Technological Pedagogical Content Knowledge (TPACK) (Mishra & Koehler, 2006; Thompson & Mishra, 2007) as a useful framework for understanding the capabilities required for teachers to work with ICT and adopted TPACK as the underlying framework.

Preparing teachers to work with ICT

Much has been written about the challenges of preparing teachers to work effectively with ICT in their classrooms. It has been described as a *wicked problem* (Mishra & Koehler, 2007), one that is complex and ill-structured, in which the context and problem definition are constantly changing, and for which there may be no agreement among experts about what might be a correct, or even acceptable, solution.

There is a significant strand of thinking and research that argues for teacher beliefs as a critical factor in ICT integration (Ertmer, 2005; Ertmer & Ottenbreit-Leftwich, 2010). More than one aspect of teachers' belief systems may contribute to capability and willingness to integrate ICT into teaching. Epistemological beliefs, that is

beliefs about what counts as knowledge, are important for establishing what teachers treat as most important for learners to learn and whether that is best learned by rote or by more constructivist approaches. Such beliefs are closely related to pedagogical beliefs about how the processes of learning and teaching should be conducted in classrooms. Teachers' integration of ICT is likely to be affected by their beliefs about what should be learned, how that is best accomplished, and the role that ICT may play in facilitating learning and teaching. Self-efficacy beliefs, that is belief in personal capability to perform the behavior required to achieve a specific outcome, are also important influences on teacher behavior, including in relation to integration of ICT (Albion, 1999).

The value of models in the development of teachers, including for integration of ICT, has been established (Zachariades & Roberts, 1995). This is consistent with the importance of beliefs such as self-efficacy beliefs because, second only to successfully performing a behavior, the observation of appropriate models performing a behavior is a powerful source of information for development of self-efficacy (Bandura, 1997). This has been recognized and supported by studies in which preservice teachers have been exposed to appropriate models in order to enhance their self-efficacy for integration of ICT (Albion & Ertmer, 2002).

More recently, Belland (2009) has argued that teachers' adoption of ICT may be better explained by the theory of *habitus*, their set of dispositions to appreciate or do certain things, which is developed throughout life beginning in early childhood. Although people are not unavoidably locked into certain behaviors by their *habitus* there is a strong tendency to adopt behaviors and chose environments consistent with it. Thus teachers often accept positions in schools that are similar to those in which they had their own education. Teacher preparation programs that seek to influence graduates toward behaviors, including integration of ICT, that were not part of their own schooling experiences face a significant challenge to provide, in a program of four years or less, experiences that will overcome the *habitus* formed through twelve years of prior schooling.

These considerations are important background to the design of courses within teacher preparation programs. The stated intention of the TTF project, to build capability among graduate teachers for ICT integration, is expected to be fulfilled by revising courses and programs to more effectively develop TPACK in graduates. Although the focus of the project is on methods courses related to the four national curriculum areas (English, Mathematics, Science, and History) already beginning implementation in schools, there is an expectation that practices that prove effective in those courses should be extended eventually to all courses in teacher preparation programs. This paper describes the evolution of one such course, *EDP4130 Technology Curriculum and Pedagogy*, and the steps being taken to revise it to more effectively develop TPACK of graduates. Technology in the course title refers to the subject specified in the Australian national key learning areas and the Queensland Technology syllabus (QSA, 2003) which in other jurisdictions might be described as design and technology or similar. It is more similar to what might now be described as STEM (Science, Technology, Engineering, and Math) than to Information Technology although information is one aspect of the curriculum.

Course design for TPACK development

The paper in which Koehler and Mishra (2005) introduced what became the TPACK framework emerged from a study in which they asked 4 faculty members and 13 graduate students participating in a faculty development course about their perceptions of elements of the TPACK framework. Analysis showed that participants had increased their thinking about all seven TPACK elements during their work on the course, which used a "learning by design" approach with a focus on developing online courses. A subsequent study with 24 participants (Koehler, Mishra, & Yahya, 2007) using a similarly structured course demonstrated development of the TPACK elements through the course and confirmed the development of stronger interconnections among the initially separate topics of technology, content, and pedagogy as the course work progressed. According to the authors, the most important part of the classes was the small group design work in which participants had to determine the design of their online course, including the nature of student interaction, delivery of content, and the use of technology to accomplish the course goals. When the participants engaged in the design task as a group they were "confronted with building a technological artifact while being sensitive to the particular requirements of the subject matter to be taught, the instructional goals to be achieved, and what is possible with the technology" (Koehler & Mishra, 2005, p. 148), thereby foregrounding the important intersections among the elements of the TPACK framework.

Design tasks have featured in the contexts of other studies in which measures of TPACK have been developed. Angeli and Valanides (2009) assessed TPACK of 215 preservice teachers using a combination of peer, expert, and self assessment in two design tasks guided by a list of criteria and reported that ICT-TPACK increased from the first task to the second. Graham, Cox, and Velasquez (2009) reported using different approaches to design within courses for preservice teachers with the intention of producing measurable changes in TPACK. The three approaches that they used were based on work with learning activity types (Harris, Mishra, & Koehler, 2009),

design challenges (Koehler & Mishra, 2005), and an integration across parallel Instructional Media and Social Science Methods courses that provided a structure within which students worked to design instructional resources using technology. Students responded very positively to the third approach but experienced some difficulty with adapting to the approach using learning activity types (LAT) because they found the concept difficult to grasp. The LAT approach has been used successfully with both inservice and preservice teachers (Hofer & Harris, 2010) but preservice teachers were found to require more support with understanding the idea of learning activities and applying them in their planning. Their need for additional support compared to inservice teachers is explained in terms of their much less extensive knowledge and experience of pedagogy, content and instructional planning. However, with appropriate scaffolding the LAT approach can be used successfully with preservice teachers in a sequence that begins by identifying learning activities in sample lesson plans and moves through purposeful selection of learning activities appropriate to particular goals to identifying technologies that might be incorporated to support an activity. Development of TPACK occurs as preservice or inservice teachers consider and discuss how pedagogy, content and technology interact to result in satisfying and effective lessons.

More recently the application of learning through design to develop TPACK in a graduate educational technology program has been described as “deep-play” (Koehler, et al., 2011). The sequence of courses within this masters program engages students in a series of design projects at micro, macro, and integrated levels. At the micro level the projects are not specifically pedagogical but focus on developing students’ comfort with the design process and offer opportunities to learn new technologies or see familiar technologies in a new pedagogical light through playful exploration of their affordances. At the macro level the projects are explicitly pedagogical and incorporate knowledge of content, pedagogy, and technology so that students engage with all aspects of the TPACK framework. The final integrated projects provide opportunities for students to reflect on their experience of the TPACK elements and develop deep situated knowledge. Working in a context that is similar to the studio environment of traditional design fields such as architecture affords students opportunities to engage in deep conversations about their practice with attendant reflection on their learning. Measurement of TPACK at the beginning and end of a sequence of design projects has confirmed the effectiveness of the process for evolving teachers’ TPACK.

Design in any sphere of activity is “a process of negotiating with multiple constraints to develop creative solutions” (Koehler, et al., 2011, p. 159). There will be functional requirements, that is, how will the designed product or process fulfill its intended function, and constraints such as time and cost limits within which the design must be completed. Often there will be other requirements such as the quality of the user experience and aesthetics to be considered. By having students engage with appropriate design tasks they can be required to consider the relationships among content, pedagogy, and technology, thereby engaging with the relationships that are at the heart of the TPACK framework. Enhanced TPACK is a logical consequence of this engagement, making design tasks a suitable choice for courses that seek to develop TPACK.

Against this background it is possible to examine the design of *EDP4130* as it has been taught and consider how it might be changed to increase its potential for developing preservice teachers’ TPACK.

Initial development of the course

A previous version of the *EDP4130* course was offered as *EDU1471 Technology Education* from 2002 until 2005 as a required course in the then current Bachelor of Education program for students aspiring to be primary school teachers. The course had originally been intended for offer relatively early in the program but was ultimately offered in the final semester of the four year program. Enrolments approximated 150 students with about 120 of those enrolled on the main campus of the university and the balance enrolled on a smaller campus about 400 km from the main campus. Both groups were taught by lecture and tutorial in face-to-face mode with classes meeting in each week of the 10 weeks of teaching available in the semester after accounting for an embedded 3 week professional experience.

The lecture series presented material about the nature of technology, technological literacy, the relevant national and state curriculum documents, international trends in technology education, curriculum planning, and assessment of technology. The lectures were presented on the main campus and recorded for replay with students on the smaller campus where a sessional instructor was available to assist students during scheduled lecture and tutorial times. The first 5 tutorials featured a sequence of activities that were mostly linked to minor assessment tasks that facilitated learning. These included a WebQuest with online discussion and a culminating debate between class groups, development and response to simple design briefs for technology activities, a letter explaining technology education to parents, and a resource review. The major assessment task engaged the entire cohort in collaboratively developing technology curriculum resources that could be made available to all members of the cohort so that all students would complete the course with a collection of curriculum resources on which they could draw as they

began their teaching careers. The task also included a requirement to reflect on their learning as it related to the technology curriculum. The design of the course was intended to model integration of ICT through the use of a website to present resources and assessments, inclusion of a WebQuest, and online discussions. Students were encouraged to use ICT in the design and development of their curriculum resources and to integrate ICT in the learning activities included in the resources.

The course ran successfully and was well received by students who appreciated the practicality of the activities offered for learning and assessment. The opportunity to create resources that would be useful to themselves and others was motivating and encouraged a level of commitment that produced high quality products.

Second edition design

The version of the Bachelor of Education offered from 2004 until 2007 did not include a specific methods course for technology. Instead treatment of the technology curriculum was incorporated in science methods courses. When the program was revised in 2007 for offer from 2008 a decision was taken to mirror the eight key learning areas that had been part of the national and state curriculum structure since the 1990s. The specification for *EDP4130 Technology Curriculum and Pedagogy* was based on the specification that had been developed for the previous technology course.

Because the previous course, *EDU1471*, had been offered successfully for several years the resources and activities were used as a starting point for development of the new course, *EDP4130*. A significant point of difference that required adjustment to the design was that by 2011, when *EDP4130* was offered for the first time, all undergraduate courses were being offered fully online as well as on 3 campuses. Hence it was necessary to ensure that all activities and assessments were designed so that students participating through the learning management system (Moodle) and virtual classroom (Wimba) would have an experience equivalent to that of students attending classes at one of the campuses. The WebQuest was revised around a contemporary issue, Coal Seam Gas, and used as a learning activity rather than as an assessment component. A simple online quiz over assigned readings, including curriculum documents, was developed and the design brief and resource evaluation activities were adapted to use the Moodle database to facilitate sharing among students. For the database activities, and some forums associated with the WebQuest, parameters were set to require a submission prior to access so that students' responses were independent of each other. The major assessable task involving development of curriculum resources was retained without significant change.

As was noted for the previous version of the course, students appreciated the emphasis on activities that they could see had direct relevance to their professional futures. That was especially true of the design brief activity, resource reviews, and curriculum materials development that generated a variety of resources that they viewed as potentially useful beyond graduation. Levels of engagement with the WebQuest activities were lower than in previous versions, most likely because it was not directly assessable and consequently was seen by students as less important. Activities managed using the database and a peer review assessment in Moodle were problematic because students were not familiar with those elements of Moodle and some found the directions difficult to follow. Similarly the final reflective activity challenged some students, who found it difficult to assess their own learning and provide evidence to support their assessments. In many instances, although the design brief activity and resource reviews met the requirements specified for assessment the content of submissions demonstrated only a superficial appreciation of the key concepts embodied in the technology curriculum and of the potential for integrating ICT.

In addition to observations by members of the course team and the regular process of inviting feedback from students, the course evaluation included a review by the ICTPO who was working with the Faculty for the TTF project specifically for its contribution toward developing students' TPACK. The ICTPO review noted that ICT was integral to the delivery of the course materials and assessment using models such as the WebQuest and tools within Moodle but that opportunities to engage students in explicit consideration of the role of ICT in support of pedagogy were missed. The conclusion was that the course could do much more to develop TPACK if it were modified to include more explicit treatment of the ways in which ICT was being used in the course and might be applied in students' own pedagogical planning.

As noted above, TPACK has been found to develop when preservice or inservice teachers engage with design tasks in which they need to consider the relationships among content, pedagogy, and technology (ICT), especially when the context encourages related conversation among colleagues (Koehler & Mishra, 2005; Koehler, et al., 2011). The conclusions about the most recent iteration of *EDP4130* reflect this and revision of the course should provide opportunities for students to engage in conversations about the relationship of ICT to content and pedagogy. Although there are challenges in using the learning activity types approach with preservice teachers and

technology (STEM) is not one of the curriculum areas for which a LAT taxonomy has been developed, there may be scope for including some aspects of the LAT approach to assist students with embedding ICT in their pedagogical.

Redesigning the course to enhance TPACK

Although the simple quiz introduced in 2011 did not address ICT integration it did serve a useful purpose in encouraging early engagement by students with key documents and helped to reinforce the broader curriculum understanding of technology as different from ICT. Its retention could be justified on those grounds but its value would be enhanced if it included items that highlight the role of ICT in supporting learning and teaching in the curriculum area.

The WebQuest about Coal Seam Gas developed for 2011 was intended to highlight the values dimensions of technology by assigning students to develop statements of position from diverse perspectives. Those statements were intended to inform participation in a discussion or debate conducted within tutorial classes or online. The absence of a product as the focus for activity and the exclusion of the WebQuest from assessment contributed to a lack of engagement from students who preferred to spend their efforts on tasks that affected assessment. For 2012 the content will be retained but students will be required to develop and present a recommendation for government policy as their final product and there will be assessment credit associated with the WebQuest. Following the approach described by Hofer and Harris (2010), students will also be asked to identify learning activity types within the WebQuest and their responses will be used to support discussion of learning activity types in class.

Design briefs are an important concept in technology education but the artificiality of having briefs developed by a group in one class session and completed by a group of peers in the next class session using materials provided by the designers of the brief has resulted in many of the design challenges being somewhat trivial. In 2011 online students participated individually in their own time. Using that approach for all students might remove some of the limitations of working in class and would free class time for other work. It would also permit a broader range of design challenges including the use of ICT as part of the challenge. That might offer some of the benefits of micro-projects for skills development described by Koehler and colleagues (Koehler, et al., 2011). Assessment criteria will be framed to encourage reflection on the relationships central to TPACK.

For 2012 the resource review activity will be replaced by an activity to be developed around learning activity types. Ideally the result would be a taxonomy of learning activity types (Harris, et al., 2009) for technology education that could be used by students in the course. Even if the product does not meet that standard it should be a useful resource for use by the students and the conversations around its development should assist with development of TPACK.

As in previous years, the major assessment will require development of a plan and associated resources for teaching the technology curriculum accompanied by a reflective report. Rather than working in a large group as in previous years students will work individually but will be required to develop a personal reference network which may include class peers but could also include teachers and outside experts on content or other aspects. The purpose of the network will be to act as a sounding board. Students will also be expected to share their products with their peers and to engage in the types of conversation that will enhance their TPACK. The focus of their reflective report will be on the process of developing their materials and the relationship among content, pedagogy and ICT.

Conclusion

The proposed changes to *EDP4130* for 2012 are evolutionary rather than revolutionary. Consideration of the experience of the course team, feedback from students, and an independent review confirmed that the course as it was offered in 2011 included some effective examples of ICT integration and was valued by students for its practical contributions to their professional knowledge. Nevertheless, the course did not deal as explicitly as it might with concepts relevant to ICT integration and TPACK. There is reason to expect that more explicit treatment of those topics would enable the course to make a stronger contribution to the development of TPACK among graduating teachers.

Review of the literature relevant to TPACK development revealed that learning through design and engagement of teachers in deep conversations about the relationships among content, pedagogy, and technology (ICT) were central to courses in which the development of TPACK had been demonstrated (Graham, et al., 2009; Koehler & Mishra, 2005; Koehler, et al., 2011). Learning activity types (Harris, et al., 2009; Hofer & Harris, 2010) as aids to planning for integration of ICT represented another important concept that could be applied to support preservice teachers in learning through design of curriculum materials and pedagogical planning. It is these insights

that are central to the changes proposed for *EDP4130* and it is hoped that their successful implementation will enhance the TPACK capabilities of students completing the course.

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