MAKING CONNECTIONS IN SCIENCE: ENGAGING WITH ICT TO ENHANCE CURRICULUM UNDERSTANDING

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Abstract

The La Trobe University iteration of the Teaching Teachers for the Future (TTF) project focused initially on subject in the second semester, third year of the Bachelor of Education course called the Multi-Disciplinary Science & Technology Integrated Experience (MSTIE). Two pairs of pre-service teachers were placed in the school where the TTF ICT Pedagogy Officer (ICTPO) worked as an ICT specialist. The two teams worked with classroom teachers and the ICTPO to cooperatively plan, teach and evaluate a science curriculum project enhanced by strong ICT integration. The experience was a catalyst for significant educational insight, for the students involved, but also for other pre-service teachers and teachers from the school and university.

In the second cycle of the project the ICTPO worked with academics from the university to draw on findings from the first cycle in order to design and implement integrated ICT initiatives in a first semester, second year Science curriculum subject. This structure means that students who will take MSTIE in their third year will have a strong foundation of Science ICT integration on which to base their MSTIE preparation and implementation.

Introduction

The "Teaching Teachers for the Future" (TTF) project (DEEWR, 2012) provided our School of Education with the opportunity to rethink the integration of Information and Communication Technology in the science curriculum subjects offered in our teacher education programs. As part of this project, we worked with two subjects, " EDU2TS: Teaching Science", a second year subject that introduces students to science curriculum and "EDU3ISL: Integrated Science Learning', a subject that builds on Teaching Science and particularly addresses the notion of integrating science across the curriculum. As part of this subject the student undertake the Multi-Disciplinary Science & Technology Integrated Experience (MSTIE), a three-week practicum experience.

Our initial design of the TTF project planned to work with the second year subject (EDU2TS) in the first semester of the project and then use the findings to design an ICT enhanced version of the MSTIE program for students in the second semester. However, because the project implementation was delayed until second semester due to a hold up in funding, we needed to rethink the sequence of the program. As a consequence, our MSTIE implementation in first semester was designed as a small case study with 4 pre-service teachers working in a school with the project's appointed ICT pedagogy Officer (ICTPO). This acted as a pilot project for a larger initiative with EDU2TS Teaching Science in second semester where the ICTPO supported curriculum lecturers to develop notions of Technological Pedagogical Content Knowledge (TPACK) (Mishra & Koehler, 2006) with pre-service teachers.

As often is the case with serendipitous events, this sequence turned out to be an ideal progression for conceptualization and development of TPACK for our science program. The case study in the school where the ICTPO also worked as an ICT support teacher gave us considerable freedom to adjust and reflect on the project design as we went. By the time the four pre-service teachers has completed their MSTIE program, we had a strong understanding of how we might best prepare a whole cohort of students for the application of TPACK when they undertook the same MSTIE program in the following year. This paper focuses on the second phase of our project, the redesign of EDU2TS: Teaching Science and describes the assessment tasks and processes we used to develop our students' understanding of how ICT can and should be used to enhance Science Curriculum.

Background

TPACK

The Teaching Teachers for the Future project draws on the framework of Technological Pedagogical Content Knowledge developed by Mishra and Koehler (2006). "Technological Pedagogical Content Knowledge" is the conjunction of three primary forms of knowledge: Content, Pedagogy, and Technology (see Figure 1).
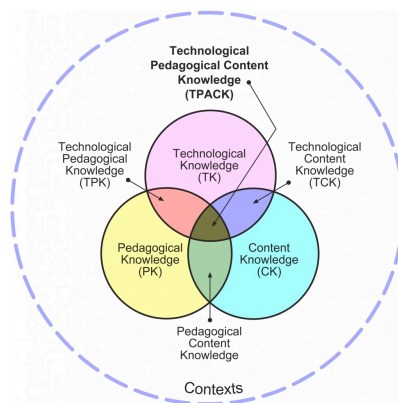

Figure 1: The TPACK model (Mishra & Koehler, 2102)

Mishra and Koehler (2006) identified that expert teachers are recognised for their capability to fuse together their deep understanding of a focus topic with skilled knowledge on how learners can learn that knowledge. However, they suggested that in contemporary times these teachers also are required to add a creative dimension where they use ICT capabilities to transform the learning experiences for their students.

Since its formulation, the TPACK model has become a framework for researchers interested in investigating the use of technologies to engender educational reform. In teacher education, this model is useful to support pre-service teachers in conceptualizing how they will use ICT in their own teaching. Typically this is done by making the model explicit to the students and then by asking them to reflect on their learning (For example, Bower, 2012). Other approaches include surveying pre-service teachers after teacher education learning experiences in order to gauge their confidence to use ICT tools and techniques in their own teaching practices (Graham et al, 2009; Jamieson-Proctor, Finger, & Albion, 2010). The first phase of our TTF project matched the first of these two approaches, as we scaffolded the pre-service teachers with ICT integration and then asked them to reflect on TPACK in their own teaching. The second phase, however, used the TPACK model in a different way. In this iteration, we knew that the students had previous experience with ICT (TK) and also pedagogical concepts (PK) but we had less confidence in their Science knowledge (CK). Accordingly, we started by presenting a task based on their known capabilities with ICT for teaching purposes (TPK) and then drew them towards Content Knowledge via this mechanism. By focusing on TPACK, we made it explicit that Science Content needed to be effectively and accurately represented via an ICT based teaching activity – a digital animation.

Content Knowledge in EDU2TS

EDU2TS: Teaching Science has a focus on the development of pre-service teacher's conceptual knowledge base, ie Content Knowledge (CK). A core idea encountered in the subject is that of the Particle Model which is introduced as a successful "thinking tool" for explaining changes to matter. In a nutshell, all matter is taken as consisting of small parts (or balls) with a certain degree of attraction to each other (depending on the substance) and a certain degree of vibrational movement (depending on the temperature) that opposes this attraction. Changes such as melting are explained by an increase in particle movement as heat is absorbed. The model is thus a dynamic one and this essential aspect is often unrecognised or misunderstood by students. The creation of explanatory animations by students was selected as a promising strategy as it enables to representation of the relationship between

dynamic and spatial features of the Particle Model concurrently. In EDU2TS, the creation of an animated explanation acted as both assessment and learning activity as students developed and demonstrated their ability to apply these central components of the Particle Model as a thinking tool.

Such representation plays a central role in science teaching and learning. How we experience and know our world depends on the languages we have for representing these experiences and knowledge. This applies particularly to science, where students are expected to learn a new literacy consisting of scientific accounts of their physical world. For students to develop these new understandings of phenomena they need to learn how to use the particular languages of science (linking appropriate vocabulary and commentary with visual and sometimes mathematical modes) to make these new understandings clear to themselves and to others.

To develop these scientific understandings, students are introduced to, and expected to use, diverse representations. These include teacher-constructed and/or provided ones (such as textbook or online material), as well as students' own representations of concepts, processes and topics. Representations relevant to this task can be further categorized as specific to the domain of science (such as animations, models, diagrams, multi-modal reports, and appropriate vocabulary and measurement for the specific topic), and generic representations used in the community and classroom. These include the use of everyday language, cooperative small group work, whole-class guided discussion, verbal reports, role-plays, debates and narratives. This second group of representations enables students to link everyday meaning-making with meanings in science. The process of constructing an animated explanation requires linking across both categories of representation. For example, the narration of the animations allows students to define and refine verbal meanings against diagrammatic representations (including dynamic aspects) in these multi-modal presentations of understanding.

There are strong pedagogical reasons for students to be given opportunities to construct their own representations. Giere and Moffatt (2003) make this point through a comparison with learning long-multiplication in mathematics. They note that many people learn to multiply large numbers that would be difficult to do mentally by using a representational framework of written numbers, symbols and manipulations. This representation functions as a thinking tool or scaffold during the manipulation, and then becomes an artefact of this thinking, shifting from a "live" representation during the process of constructing an answer to a "dormant" representation, unless used for more re-interpretive thinking. A mathematics teacher would not consider students "mathematically competent" in long-multiplication if they had never practised this computation, but had just observed the constructed representation and learnt to recall it by rote. For Giere and Moffatt (2003) the same idea applies in science learning, where students should learn how to use representations such as animations as thinking tools for understanding and explanation, rather than memorizing and regurgitating "correct" representations for knowledge display.

The actual process of constructing a scientific explanation acts as more than just a signifier of developing "scientific competence"– it is perhaps how such knowledge structures are best built. This follows Seymour Papert's Constructionist idea that learning "happens especially felicitously in a context where the learner is consciously engaged in constructing a public entity, whether it's a sand castle on the beach or a theory of the universe" (Papert & Harel, 1991:1). Creating a representation of understanding may best facilitate learning as the increased time required for construction allows testing and consolidation of understanding by the students.

Project Implementation

For Phase Two of our Teaching Teachers for the Future Project we decided that the ICT Project Officer (ICTPO) would support the Science Curriculum Lecturers in order to incorporate TPACK into EDU2TS: Teaching Science. In Semester 1, 2012, this subject had 205 enrolled students, drawn from the Bachelor of Education and the Bachelor of Physical and Health Education.

Subject Design

Before the semester started the ICTPO attended a planning meeting to help review the Subject Learning Guide. In particular the team decided to incorporate an assessment task, worth 30%, to

address the following intended learning outcome:

Develop and represent accurate understandings of key physical science concepts (VIT Standard for Graduating Teachers 2.2)

While, due to University regulations with the timing of database changes, this ILO remained in place for the Semester 1, 2012 implementation, it is anticipated that the next iteration of the subject will address the following standards from the new National Professional Standards for Teachers (AITSL, 2012).

2.1 Demonstrate knowledge and understanding of the concepts, substance and structure of the content and teaching strategies of the teaching area.
2.6 Implement teaching strategies for using ICT to expand curriculum learning opportunities for students.

The task designed for the project was a 'Chemistry Animation' where the students worked in pairs to create "a digital animated presentation in which you are to use particle model ideas to explain an observable change from a chemistry perspective". This animation needed to be less than three minutes in length and required students to integrate clear explanations, describing which aspects of the animation addressed specific chemistry concepts and how. The students were told that the chemistry concept should be drawn from VELS level 4 or higher and the concepts would be covered in the subject lecture program.

The animation could be created in any software application including web-based programs like "Animoto" and mobile apps such as "Brushes". More traditional software environments were suggested too, like "Movie-maker", "i-Movie" and even PowerPoint. The students were required to upload their animation to a hosting site such as Vimeo or YouTube and then create a reflective page as an interface to the video link in "Pebble Pad", the Personal Learning System provided by the University.

Task implementation

The role of the ICTPO during the six-week task implementation was to scaffold the students and the lecturers to use ICT effectively for their animations. In order to immerse in the process, he attended the lecture program so he would be familiar with science content being presented to the students. He also attended the University campus for one day per week so students could arrange appointments with him. He also provided support via email. The ICTPO assisted the students to progress through the design cycle for the task including modeling strategies for helping them to think laterally and creatively about their animations, planning and storyboarding, and problem solving when things went wrong.

Another important role for the ICTPO was to liaise with other support staff available to the students. This included the Digital Media Technician employed by the School as a media construction specialist and the e-learning mentor, a student with ICT expertise who was available to work one-to-one with other students. He also helped students use the specialist equipment in the digital media lab including recording options and a green screen and then he supported them when they needed to consult the University IT services, particularly for network access and firewall issues.

Finally the ICTPO provided some useful resource examples for the students as they conceptualised what was required. Some of these examples were sourced from teachers and classrooms from his school and teaching experiences but some also came from the previous phase of the TTF project and were created by students in the MSTIE experience.

Outcomes

During the six-week period of construction, and particularly during the last two weeks before the task was due, the building was a hive of activity. The students appeared to engage with the task and many made the most of facilities available to them including access to the ICTPO and other support staff and

the use of specialist software and equipment in the digital media lab.

In total, 150 animations were created using a wide range of software and animation techniques. While PowerPoint was a safe option and a popular choice, many students sourced specialist software including applications that they could use on their iphones. One pair reflected on the importance of exploring the software thoroughly and lamented that they had downloaded an app titled 'stopmotion' (one word) rather than a more user-friendly application, 'stop motion' (two words) that other groups had used. While stop motion was the most common technique, there were a variety of mediums including cut paper, Claymation, drawn animations, photography and mixed medium.   The science concepts depicted in the animations varied too and included dissolving particles (see Figure 2) gas/liquid transformation, melting solid to liquid (chocolate and ice cream were popular), burning reactions, hot air balloon concepts and "how smell gets to your nose".
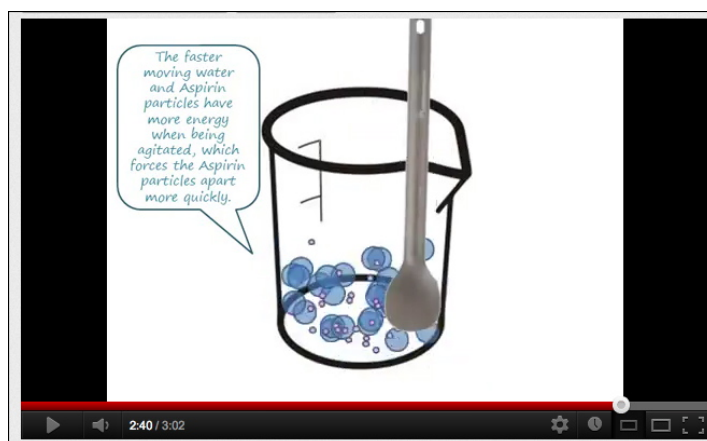

Figure 2: How aspirin dissolves with agitation

Although the reflective page was only required to be brief, some interesting observations emerged from this component. Quite a few of the groups commented how they were surprised how long it took to make the animation. Others described how valuable the teamwork was, particularly when it came to clarifying the science concept that they would depict. One group realized that they really didn't have a good grasp of how a hot air balloon worked at all, because they really struggled to articulate the idea to each other.

Some of the students extrapolated how they might use their animation in the classroom. One group identified that they revised the script for their animation many times because they wanted to use the best possible vocabulary for the explanations. They clarified that if they used 'jargon' without explanation in the animation then it was likely that the meaning would be lost. A few of the reflections also pointed out that although the children in a class may learn about the concept if they watched the animations, they would learn more if they actually went through the process of creating an animation for themselves.

The Subject Coordinator of EDU2TS reported that the support of the ICTPO extended the task significantly. He was really happy with the assessment task and thought that it engaged the students effectively with the lecture content. He did note though that while many of the submissions clearly demonstrated that the developers had a good grasp of the content, it was very evident if the student really didn't understand the scientific principles involved. For example, one of the submissions was entertaining and beautifully animated but the particle spacing and movement did not reflect the scientific view.

Conclusion

While the sequence wasn't as initially planned, the second phase of our TTF project effectively extended findings from a pilot study in the first phase to a whole cohort. In this iteration, a TPACK based task was incorporated as assessment in order to establish ICT integration as a validated component of the curriculum subject, EDU2TS. This implementation was highly successful and the

teaching team were pleased with the pre-service teacher engagement and the artefacts produced. As a consequence, the task will become an ongoing component of the subject. It will also be interesting to monitor how the students from Semester 1, 2012 will choose to implement ICT in their MSTIE program when they are required to design it in Semester 2, 2013.

The TTF project has been influential for our course design and has helped to establish TPACK as an important component of our teacher education program. The implementation of TTF in our science curriculum has demonstrated how a specialist teacher from a school can be used to support university lecturers. It also established how we should connect with our specialist staff within the university for teaching purposes and how we should make the most of the facilities and equipment we have at university. This project has served as an exemplar to inspire and engage lecturers across all curriculum disciplines.

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Graeme Draaisma. Preparing students for the world they live in and incorporating ICT into all aspects of the curriculum is a passion of Graeme Draaisma, ICT teacher at Golden Square Primary School, Bendigo. He uses student led projects to engage students and give them opportunities to explore, create and share. Graeme has been involved in teaching and learning teams that promote collaboration and reflection to develop a performance improvement culture. This was an important element in the successful research project undertaken in partnership with LaTrobe universities.