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EXAMINING HOW TEACHERS USE WEB 2.0 TECHNOLOGIES IN SCIENCE LESSONS TO PROMOTE HIGHER ORDER THINKING SKILLS IN TEACHING SCIENCE

During 2007 several independent Victorian secondary schools participated in a study exploring the ways in which the use of learning technologies can support the development of higher order thinking skills for students. This paper focuses on the use of Information and Communications Technologies (ICT) including Web 2.0 technologies for promoting effective teaching and learning in science. A case study methodology was used to describe how individual teachers used ICT and Web 2.0 in their settings. Data included interviews (focus group and individual), questionnaires, monitoring of teacher and student use of smart tools, analysis of curriculum documents and delivery methods and of student work samples. The evaluation used an interpretive methodology to investigate five research areas: Higher-order thinking, Metacognitive awareness, Team work/collaboration, Affect towards school/learning and Ownership of learning. Three cases are reported on in this paper. Each describes how student engagement and learning increased and how teachers’ attitudes and skills developed. Examples of student and teacher blogs are provided to illustrate how such technologies encourage students and teachers to look beyond text science.

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Introduction

The project: The Development of Thinking Skills Through ICT was proposed in response to the fact that many teachers have not recognised the potential or capabilities of new Web 2.0 technologies for their own teaching and students’ learning (Levin & Arafah, 2003); nor do all teachers have the necessary technological or pedagogical skills to teach using these type of technologies (Mishra & Koehler, 2006). Mishra and Koehler argue that while many teachers are aware of the uses of various technologies and the skills needed to use these technologies, they have not developed a pedagogical intent for their uses. The primary theoretical framework underpinning the integrated pedagogical and technological approach for the project included five components: Choice, Effort, Quality, Attitude, And Labour of Love [CEQ.ALL](March, 2006) and the project focused on five areas identified to enhance students’ thinking skills: Higher-order
thinking, Metacognitive awareness, Teamwork/collaboration, Affect towards school, Ownership of learning. These five focus areas are consistent with recognising the need for both individual and social opportunities for construction of meaning, and intrinsic and extrinsic motivations for learning. This project provided teachers with opportunities to be creative and explore the pedagogical potential of these technologies in the classroom.

Background

Loughran, Berry and Mulhall (2006, p. 9) have described pedagogical content knowledge (PCK)\(^1\) as “the knowledge that a teacher develops over time and through experience, about how to teach particular content in particular ways in order to lead to enhanced students understanding”. Each teacher’s expertise in knowing how to teach a specific discipline area is unique and cognisant of the subtleties, meanings and interpretations that the discipline demands. The PCK framework originally proposed by Shulman has proved to be instrumental in changing teacher’s education to focus on the way the content is taught - helping teachers to become aware that pedagogical knowledge is an area of expertise. Mishra and Koehler has adopted the PCK framework, to focus on the use of technologies within specific discipline areas, explaining that “good teaching requires an understanding of how technology relates to the pedagogy and content” (Mishra and Koehler, p. 1026). This paper uses the theoretical framework of the technological pedagogical content knowledge\(^2\) (TPCK) as a foundation for the analysis and examination of how teachers use technology effectively in the classroom. TPCK: “requires an understanding of the representation of concepts using technologies; pedagogical techniques that uses technologies and how technology can help redress some of the problems that students face.” (Mishra & Koehler, 2006, p. 1029). The development whereby teachers are “learning technology by design” (p. 1034) is utilized in this project to develop teachers skills and confidence to allow them to create individualised lesson plans that address the content, technology and pedagogy – thus creating a whole learning experience that is more effective than the sum of the parts.

Higher order thinking skills include creating, evaluating and analysing (Atherton, 2002) and pedagogies that promote these skills are varied but include challenging the learner, promoting active participation, argumentation, problem solving, conducting investigations and tackling subject matter that is complex (Tytler, 2004).

Web 2.0 is a term to describe the evolution of technologies that make greater use of the web browser interactivity capacity to allow the user much greater power, personalisation and participation (Hinchliffe 2008; O’Reilly, 2005). Software and applications such as Google Maps, Wikipedia, Facebook, Blogs, Flickr, podcasting, RSS feeds, and social bookmaking have developed in response to these increased capabilities.

\(^1\) PCK will be used as abbreviation for Pedagogical Content Knowledge (PCK)

\(^2\) TPCK will be used as abbreviation for Technological Pedagogical Content Knowledge (PCK)
Web 2.0 technologies make use of the Internet to allow greater collaboration and sharing of resources among a community of learners. The technologies include wikis, blogs, RSS feeds, social bookmarking and social-networking sites. Individual users can remix and recreate data – searching, selecting and creating new interpretations and presentations of data that meets their personal requirements. In this way the Web 2.0 technologies have great potential for teaching and learning, not only providing students with access to information, but more importantly allowing students to choose, create, evaluate and interact with a selective or global audience. This project uses “Web 2.0” software to take advantage of digital technology’s power to engage students in personalised learning that promotes thinking skills.

Ubiquitous computing describes the widespread way in which computers and our lives are becoming indistinguishable (Ley, 2007). Generally younger people have greater expertise with these technologies than older people - evidence of the digital divide (Prensky, 2001). Research has shown that the presence and use of the technologies are influencing the way people learn, with increased visual genres, greater interactivity, and immediate feedback. Because the systems of technologies are changing at a rapid rate that has not previously been observed, teachers are faced with the challenge of constantly learning new skills needed to use the new technologies with which students are often more familiar than the teachers. ICT is an area all teachers are responsible for and one they must include in their teaching and hence there is a need for all teachers to be able to teach using ICT effectively (VCAA, 2005).

Aim and Methodology

The aim of this study was to explore the way(s) in which effective use of learning technologies can support the development of higher-order thinking skills in students. To achieve the effective use of learning technologies the teachers were provided with an ongoing Professional Development (PD) program with instruction in the pedagogy of using Web 2.0 technologies as well as instruction in the Web 2.0 technological skills. The PD program included an emphasis on a student-centred approach to teaching, empowering the students to think for themselves, incorporating strategies to promote life long learning and academic optimism. The educational consultant used the framework CEQALL – choice, effort, quality, attitude, and labour of love to encourage teachers to re-evaluate how they use the online resources in classrooms so that these qualities can be promoted. Through the CEQALL framework “education can better position itself if it focuses on a pedagogically more honest approach enabled by technology: enabling individual growth and learning.” (2006, p. http://tommarch.com/ceqall/)

Teachers were responsible for the implementation of the technology - designing teaching material that incorporated the technologies into their lessons. The focus on Web 2.0 was not on the technology but rather how the technology could be used to promote higher order thinking by using it on tasks that required, for example problem solving, reflection, and cooperation (Fogarty & McTighe, 1993). This paper reports on teachers’

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3 PD will be used as abbreviation for Professional Development
incorporating technologies into their lessons to promote higher order thinking by addressing the research questions:

1. How do teachers use technology effectively in the classroom?

2. How do the technologies promote higher order thinking? i.e. What pedagogical aspects of the teaching that used learning technologies promoted higher order thinking skills?

The evaluation uses an interpretive methodology utilising a range of data including monitoring students’ and teachers’ use of various smart tools, analysis of curriculum documents and delivery methods, analysis of student work samples, interviews, focus groups, and questionnaires about computer skills and professional development programs (Anderson, 2004).

Thirteen teachers from six well-resourced schools in Melbourne, Victoria participated in the project. They were introduced to the philosophy of the program and 3 months later, began trialling the online resources, after another 3 months they participated in a 3 day PD program during the school holidays, after which time the teachers began implementing their new programs, with a follow up PD day 3 months later. The participants came from a variety of subject areas with students of various age groups. The uptake of the technology varied across the group. This paper focuses on three teachers, Tom, Deb and Jackie (pseudonyms) who used the new technologies most extensively and effectively. Data describing their practice will be used to address the research questions. Discussion of all the participants is reported elsewhere (Chittleborough, Jobling, Hubber, & Haslam, 2007).

Analyses and Findings

All thirteen teachers established a class portal through which they directed students to various activities and tasks. The scope and depth of the class portals varied. Teachers used the class portals as a source of information, to invite comment, provide links to worksheets, and provide links to motivating websites. Some teachers gave students choice of learning activities within the portal, others used the portal as an information source.

The five focus areas identified to promote Thinking Skills: Higher-order thinking, Metacognitive awareness, Team work/collaboration, Affect towards school/learning and Ownership of learning were addressed by various parts of the MyPlace website (see Table 1)
Table 1 Addressing Thinking Skills — support from the MyPlace website

<table>
<thead>
<tr>
<th>Focus Area</th>
<th>MyPlace website</th>
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<tbody>
<tr>
<td>Higher-order thinking</td>
<td>Examples using various Thinking Routines e.g. see-think-wonder Learning to Look — probing, seeing questions</td>
</tr>
<tr>
<td>Metacognitive awareness</td>
<td>Teachers were encouraged to use the CEQALL framework that promotes student-centred tasks.</td>
</tr>
<tr>
<td>Team work/collaboration</td>
<td>The ‘Teachers’ blog on the myspace site was not well used.</td>
</tr>
<tr>
<td>Affect towards school/learning</td>
<td>Using “compelling web resources” to inspire Instilling the importance of Choice, Effort, Quality, Attitude, And Labour of Love (CEQALL) in their teaching.</td>
</tr>
<tr>
<td>Ownership of learning</td>
<td>Empowering the students with the technologies; providing greater choice and flexibility through class portals.</td>
</tr>
</tbody>
</table>

**Higher-order thinking**

The MyPlace website describes and models various thinking routines that can promote higher-order thinking. These were used by some teachers, for example one Year 6 teacher explained ‘we did ‘See, Think, Wonder’ activities and we explicitly taught Thinking Skills ... used them during numeracy, literacy activities and so on ... the children love it and they have produced some great work’. One key way in which the technology was used to promote higher order thinking was to pose questions based on visual and audio stimulus material. Examples of pedagogies used by the teachers that provide opportunities for higher order thinking in this project include:

- setting challenges and posing big questions that require analysing and evaluation.
- encouraging students to respond sharing opinions ideas and research
- using thinking routines and thinking frameworks to promote thinking e.g. concept maps, PMI, thinking hats and thinker keys.
- including reflective tasks
- pushing students outside their comfort zone
- providing good stimulus material such as animations, video clips, podcasts.

**Metacognitive awareness,**

Blogging gave students an additional communication space that provided new opportunities to raise awareness of their own learning. Some teachers used the blog as a
source of information, to invite comment, provide links to visual, audio and text resources. Some students responded eagerly to teachers' requests, challenges or questions, for example searching the web for good links that provided answers to questions.

Students from Azalea school, when interviewed about blogging, revealed an appreciation of the learning opportunities for example:

S1 If you are in the classroom many people could talk at once. But you are doing it here and you only hear, see or pick what you want to listen to.

S2 It is easier to understand, sometimes it becomes clearer.

S3 Sometimes it is clearer when they write it down.

S4 It was good because you think about when you go home. It is something to think about and when you find it, when it is a good answer or something you can add it on, you can add it straight away don't have to keep it and wait to the next day.

Int: Did you read their comments did that make you think?

S3 Yes, and also it is good to see like, the different points of view, like one person might have one comment whereas another person might add to that comment, to say something extra.

One teacher, named Deb (pseudonym), encouraged her students to post questions on the blog as a means of managing dominant class members. She appreciated that the blog can provide an alternative learning forum:

Deb: Students that struggle with Science have found they can fully participate as questions and comments on blogs are their opinions. They have a chance to think before they respond, and read other people's comments - so they are able to give a more considered opinion or explanation than is possible during a lesson.

Some students tended to be very uncertain about posted the minimum requirements. Blogging as a school task may be viewed differently by some students – aware that their postings are overseen with implications of assessment, conventions of language and not willing to risk criticism by peers or the wider community.

Team work/ collaboration

Towards the end of the project there was some collaboration among the teachers. It occurred when one teachers posed a challenge to other. It highlighted the that the collaboration depended on the teachers being willing to be involved; the task needed to be scaffolded and have a relevant purpose and match the needs of the teachers and students.
Affect towards school / learning

The case studies provide examples of students developing positive and active interests in their learning. One teacher, Tom has a website that promoted an interest in science. A student, from Tom's school rang a program in US to advertise his teacher's website. Here is an excerpt of the conversation:

Student: I have been asked by my teacher to give you a website. His aim is to get 10,000 hits before the end of term.

TV Presenter: Don't you think it's cool that you have a science teacher with his own blog, and he does podcasts too...

Student: Everyone at school visits his website

Ownership of learning

Teachers included choice as a critical component of many tasks, providing students with some ownership of their own learning. Ownership has proved a powerful aspect to promote intrinsic motivation and foster students' learning. Students recognise and acknowledge that they are being given a choice and therefore ownership of their learning. A response by a student in the focus interviews, exemplifies this:

Student: If you need to do a specific thing, if you choose which one was relevant to what you need to look for, you could go into that straight away and then that tells you what you want.

Interviewer: Have you noticed a change in the way of learning science?

Student: Yes like normally for homework do questions 7 to 8 is like look at this page and you might like to add a question or something or visit another site to do revision.

The Case Studies

Case Study 1:

Tom's webpage for a Life Learning unit in a Grade 9 science class included challenges, homework questions, practical lessons and a blog. The PD provided an opportunity for him to get expert advice and training in the use of the technologies. He set challenges about big issues – such as Sports Science; Space Travel; Blast; Nuclear War; and Life on Another Planet. He provided teasers to get students interested but gave them the challenge of finding out and presenting answers to questions. Evidence from Tom’s response to interview questions show how he intentionally included tasks that focused on the five CEQALL attributes – see Table 2.
Table 2 Tom’s perceptions of students’ learning experience in relation to CEQALL

<table>
<thead>
<tr>
<th>Choice</th>
<th>“All students embraced it (the challenge/project) with enthusiasm”...It was designed to be relatively unstructured to enable students to be more self-directed”.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effort</td>
<td>The project “had really intrinsically motivated students to want to do well”.</td>
</tr>
<tr>
<td>Quality</td>
<td>“Students had discovered things that they did not know and on occasions at least 50% of the students experienced the flow of wanting to know... this reflected on the final presentation of the project work which was generally excellent and better than any other work I had seen in the previous years”.</td>
</tr>
<tr>
<td>Attitude</td>
<td>“I do feel that students were still extrinsically motivated by marks, however, there was also some intrinsic &quot;need to know&quot; going on too.”</td>
</tr>
<tr>
<td>Labour of love</td>
<td>“I feel that I never achieved 100% learning purely and simply for the sake of learning. The problem probably lies in the fact that assessment and reporting are such a big focus at schools. So in an attempt to help my students love learning and want to learn I set up another site which is my blog of interesting things going on around the world. I have given the site to the 80 kids I teach this year and in eight weeks this term since its introduction it has got about 1500 hits. So I feel it is somewhat successful at helping kids want to learn and as such I plan on keeping it going”.</td>
</tr>
</tbody>
</table>

In February 2008, Tom’s blog was featured on a TV program called ‘The Lab with Leo Laporte’ in the US - after a student informed them of Tom’s challenge to get 10,000 hits before the end of term. The site Tom’s site had 66,000 hits in September 08. Tom has made numerous pod-casts on Senior Biology and has a +300 download count from his I-tunes site; he is developing the website for the Grade 9 school trips - to China Vietnam, Fiji and Central Australia and has trained four other staff members in developing the website.

To promote higher order thinking - Tom used the technologies to provide choice that fostered motivation and interest. The questions set challenges within boundaries and students had the capacity to answer - with the web as the source of information, thereby giving students greater control and ownership of the task. Tom described the students’ work as in the higher order range of thinking – “the projects the students created were certainly at the top end of Bloom's revised taxonomy. ie. Analysing, Evaluating and Creating. So it was terrific in this regard.”

Case Study 2

Deb has also made several class portals – such as May the Force be With You and Changes of States for a Year 7 science class. Deb wanted a site that presented science as fun and engaging. Some common characteristics are: personalizing the site with photos of
students conducting activities; a motivating or attention grabbing clip e.g. newsworthy videos of a ship that ran aground in Newcastle, NSW was used as the basis of a discussion about forces; encouraging students to look for and assess material on the web to solve problems; and a variety of games and revision tasks –on the topic.

Deb commented that the web interface was more connected to the students’ experiences and provided excellent stimulus resulting in rich student conversations on the blog. Her students generated their own definitions requiring higher order thinking. For example students’ blog responses to a question about an image showing mist above a lake:

“Obviously in this picture the water from the lake/sea is evaporating.”

“I think that the water is evaporating even though it has not reached its boiling point [100 degrees] because some of the water molecules have just enough energy to become gaseous.”

Deb was keen to cater for the digital natives and identified changes in her pedagogical approach, for example:

- Using short clips that go for 5 minutes, like from You-tube rather than videos that go for half an hour.
- She used the blog as a additional forum - that helped manage students’ questions in class.
- Students have been given much more choice and opportunity to direct the curriculum.
- The questions on the blog can be addressed at a number of levels allowing all students the opportunity to respond.
- Students have greater flexibility and can access the Internet for class notes at anytime.

Similar to Tom, Deb commented how the students feel empowered when given choice in their learning.

Case Study 3

Jackie begin with the Teenage Affluenza You-tube clip and one of the thinking tasks suggested by the educational consultant. It promoted a lot of discussion and its success could in part be gauged by the way in which students’ interest and thinking were stimulated. She set up a wiki on which girls discussed issues around a community project. In addition Jackie had a blog and website. By February 2008 Jackie was working with teachers at her school on the use of wikis and discussing with teachers how blogs can be used to support learning programs. She had also commenced work on her own blog using wordpress and was writing about Web 2.0 and how teachers can use new technologies to support learning. Jackie’s blog shows the growth of her own use of Web 2.0 technologies:

Two years ago I felt overwhelmed by the wealth of information flooding from the Web: today, not so much. I think this is because the type of reading I am doing has changed. An essential part of my reading today is via my
Google Reader. Here I access the latest feeds from people who write blogs that are of interest to me. Most of these are people involved in education from various corners of the world. These people are filtering the information overload that is the Web for me, and I, in turn, am doing my bit by writing this blog and adding to the filtering process. By being part of this community I am helping to manage my own professional development and hopefully am assisting other people with theirs.

Jackie’s blog has resulted in her forming an extensive network of fellow educators using these technologies to enhance student learning. (Jackie’s map shows over 8 000 visits between February 2, 2008 and August 18, 2008.) Evidence of the power of the network and the technologies for student learning is exemplified by a global cooling project a group of her students completed in their own time (as it was outside the year level’s curriculum). It began through linking students, teachers and principals from Korea and the USA and Jackie’s school. It culminated in a concert organised one weekend late in April 2008 to raise awareness and involved thirty-two students over a period of eight weeks. Jackie’s story is significant in highlighting the fundamental change in her use of the technologies and way of approaching teaching.

Discussion

In all three case studies the teachers had an excellent understanding of the CEQALL framework and produced pedagogically sound websites that appear to have had a positive influence on learning. The evidence from each of the case studies is rich but the sample is small, however, it suggests that the instruction through the PD helped these teachers to situate the technologies meaningfully within their teaching. Students’ choice and ownership of their own learning was identified by the teachers as a powerful motivator and initiator of learning in each of the case studies. This approach is student-centred not technology centred. Using approaches that are flexible and varied and allowing choice proved significant.

While the CEQALL framework is at the interface with students the TPCK framework has potential to help identify key ways for the teacher to use the technology. The TPCK framework includes the technology integrated with the teaching and the content. The technologies used included websites, podcasts, you-tube clips, and blogs among others. These media formats link to those with which students identify and may already be skilled and familiar. The potential of the learning communities to inform and broaden understanding was demonstrated in the case studies. The key ways in which the technology was used was as: visual and audio stimulus material, to provide access to current data, to allow students greater choice and consequently ownership of their learning, to provide an alternative form of communication to traditional means – for example through the blog among class members and the teachers; the use of technologies that provide feedback to students through blog responses, websites and immediate feedback through interactive games. In these ways the technologies provided
opportunities for higher order thinking. Success is dependent on the teacher situating that task that promotes thinking in the content, through for example a problem or challenge. As the TPCK framework indicates, the technologies alone do not promote higher order thinking.

Conclusions

The project resulted in the development and extension of existing pedagogies as teachers capitalised on the characteristics of the Web 2.0 technologies. Teachers incorporated the technologies in creative and meaningful ways to support existing curriculum and content to promote the development of thinking skills. They were encouraged to adopt new delivery methods using Web 2.0 technologies such as blogs, podcasts, and class portals. Students, in turn, responded to stimuli, conversations and challenges and reported feeling ownership of their learning due to the personalization and participation that this approach offered. Students were able to be creative when using digital technologies to represent ideas in multiple ways. Their work reflected the development, to varying degrees of the five thinking characteristics. Teachers set challenges and posed big questions that required students to analyse evaluate and use other thinking routines. Teachers valued students’ responses and opinions and provided them with varying degrees of choice as to what and how they learnt. They created a digital learning community where Internet resources, web-based forums, and digital resources were used. This allowed for easier access, greater flexibility and more interactive programs for students. The greatest learning potential of the Web 2.0 technologies was demonstrated in the interactivity and communication that took place amongst some members of the online community. The Web 2.0 technologies used provided all members with ample opportunities to remix, recreate, respond to others and construct meaning.

Some characteristic teaching approaches – not necessarily unique to the Web 2.0 learning technologies, but supported by them - that were used to create learning opportunities to support thinking, included:

- having a purpose to all tasks;
- situating these in a meaningful, authentic context;
- accessing and using stimulating original material commonly including audio, visual and text data;
- giving ownership to students;
- providing feedback;
- allowing choice so students could direct their own learning;
- promoting a love of learning.

Some of the active and passive capabilities of the Web 2.0 technologies in school learning situations primarily were demonstrated through
communication among teachers and students by using various structures such as weblogs;

- accessing /sharing information, getting feedback reconstructing data, responding to data, etc.;
- being a repository of information, data that allows flexibility and choice in when and how the information will be used.

utilization of various modes of data—such as video, text audio through a variety of formats—e.g. class portals, podcasts, and Internet links (including links to animations, simulations and interactive sites).

The importance of online/digital learning communities are developing as significant ways of learning that utilise new technologies. Some significant aspects identified in this project include the triggers or reasons to write or respond, stimulus material, consistency in postings, developing an online presence and personality and building confidence in online writing. There was direct evidence of the development of higher order thinking in students’ tasks such as Web-quest, blogging and challenges that encouraged analysis, evaluation and creativity.

References


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