USING THE INTERNET IN HIGH SCHOOL MATHEMATICS

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Abstract

Whilst the technological, pedagogical and content knowledge (TPACK) model has been increasingly adopted for understanding teachers' use of technology, there have been many calls for greater discussion about the constituent constructs, their relationship with one another and the central TPACK. This paper analyses qualitatively the TPACK demonstrated by the teacher of a Year 11class who used web-based simulated contexts and interactive web objects in a Mathematics Studies course. The findings indicate aspects of TPK relating to academic learning time and the transformational mode of the technology were not fully realised in this case study. The implications these has for teacher professional development are discussed.

Keywords: Classroom Teaching, Interactive Learning Environments, TPACK, Mathematics Education, Pedagogical Issues.

Abstrak

Sementara model tentang pengetahuan teknologi, pedagogi, dan konten (TPACK) telah semakin diadopsi untuk pemahaman guru tentang penggunaan teknologi, ada banyak masukan untuk diskusi yang lebih besar tentang konstruksi konstituen, hubungan mereka antara yang satu dengan yang lain dan TPACK pusat. Tulisan ini menganalisis secara kualitatif TPACK yang ditunjukkan oleh guru dari kelas 11 yang menggunakan konteks simulasi berbasis web dan objek web interaktif dalam program Pembelajaran Matematika. Temuan dalam penelitian ini, menunjukkan bahwa aspek TPK yang berkaitan dengan waktu belajar akademik dan mode transformasional teknologi tidak sepenuhnya diwujudkan dalam studi kasus ini. Implikasi nya terhadap pengembangan profesional guru, juga akan didiskusikan.

Kata Kunci: Pengajaran di Kelas, Suasana (Lingkungan) Pembelajaran Interaktif, TPACK, Pendidikan Matematika, Isu Pedagogi

With advances in technology such as increased bandwidth, wider Internet coverage and increasing number of stand-alone and web-based education related software, teachers are expected to be able to use the technology available in schools to improve teaching and engage students in learning. However ICT pedagogy in general, and web pedagogy in particular remains largely unaddressed in schools (Bain & Weston, 2012; Baskin & Williams, 2006). It is valid to say there still exists what Trend, Davis and Loveless (1999) termed a 'reality-rhetoric gap' when it comes to effective integration of ICT into mathematics learning situations. The rhetoric is that digital technology has potential to transform the way learning is being carried out but the reality is teachers are still grappling with how best to do so. Numerous studies undertaken to determine the ways ICT has been utilised in the classroom showed that ICTs were rarely used in new ways but showed characteristics of traditional approaches to learning (Smeets, 2005) or supplemented existing classroom practices (Hayes, 2007). Mathematics teachers need professional development to meaningfully integrate technology so that it can contribute positively to the teaching and learning of mathematics (Goos & Bennison, 2008; Handal, Campbell, Cavanagh, Petocz & Kelly, 2013; Joubert, 2013). Professional development programs need to include modelled planning and pedagogy with the technology in teaching specific mathematics topics (Goos & Bennison, 2008; Lee & Hollebrands, 2008). Research has found that despite preservice teachers' confidence in being able to incorporate technology into their future mathematics teaching and shifting from thinking about technology as a reinforcement tool to one for developing understanding, they remain sceptical about the appropriateness of using technology in mathematical concept development (Ozgun-Koca, Meagher & Edwards, 2010). How best to support teachers in their quest for meaningful and seamless integration of technology for transformational learning appears to continue to be a pressing issue.

In trying to make sense of how ICT can be better integrated into learning instruction several frameworks were suggested (for e.g. Lim, 2002, Twining 2002, Mishra & Koehler, 2006). One framework that has been increasingly adopted by many education researchers and theorists is the Technological, Pedagogical Content Knowledge (TPCK) framework by Mishra & Koehler (Mishra & Koehler, 2006; Koehler & Mishra, 2009). In this framework, Koehler and Mishra argued that while teachers' knowledge about content (CK), pedagogy (PK) and technology (TK) is vital for quality teaching, they cannot be viewed in isolation. Hence, in addition to the term pedagogical content knowledge (PCK) coined by Shulman (1986), Mishra and Koehler (2006) suggested two new pairs of knowledge constructs which are technological content knowledge (TCK) and technological pedagogical knowledge (TPK), and a triad of knowledges: technological, pedagogical, content knowledge (TPCK) which was later renamed as technological, pedagogical and content knowledge with a new acronym (TPACK) (see Figure 1). This framework suggests that these three pairs of knowledge constructs (PCK, TCK and TPK) and the triad TPACK are exhibited or are evident in teachers who use technology effectively.

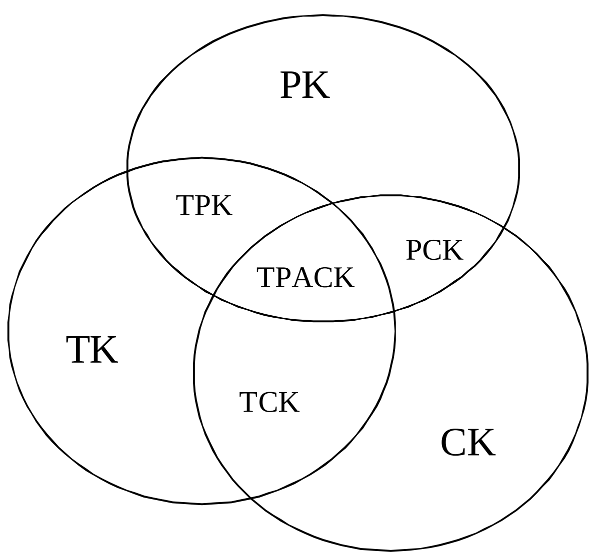

Figure 1. the TPACK Framework (Koehler & Mishra, 2009)

Pedagogical Content Knowledge (PCK) is about knowing which teaching approach fits what content and having the teaching strategies that help make difficult concepts comprehensible to learners (Shulman, 1986). Technological Content Knowledge (TCK) refers to knowing how representations of the subject matter can be changed through use of the technology (Koehler & Mishra, 2009) and Technological Pedagogical Knowledge (TPK) is knowledge about the existence, components and capabilities of various technological tools as they are used in teaching and learning situations (Koehler & Mishra, 2009). The triad knowledge construct, Technological, Pedagogical and Content Knowledge (TPACK) suggests an integrated understanding of the three pairs (PCK, TCK and TPK) or a third entity.

In this paper, a case study methodology has been adopted to analyse one teacher's TPACK and its impact on his classroom practice and students' learning outcomes. This paper explores the following research questions:

1) To what extent is the teacher's TPACK evident when using the Internet?
2) To what extent are the learning goals met as perceived by students and teacher?
3) What are the teacher's perceived TPACK needs?

Teachers' knowledge in successfully integrating technology into mathematics has been an area of concern (Goos & Bennison, 2008; Joubert, 2013). While the TPACK model for framing teachers' integration of technology in education is increasingly cited, there have been calls to shore up weaknesses in the clarity of TPACK construct definitions and in articulating how the constructs are related to each other (Graham, 2011). Several studies have begun to do that. One study using structural equation modelling (Koh, Chai & Tsai, 2013) showed that while in-service teachers perceived TPACK to be formulated from the direct effects of technological knowledge and pedagogical knowledge which contribute to the development of technological pedagogical knowledge (TPK) and technological content knowledge (TCK) which in turn contributed to TPACK, the effects of content knowledge and pedagogical content knowledge were found to be not evident. They attributed that to methodological and contextual reasons. Studies on pre-service teachers' TPACK showed that as their pedagogical knowledge increased by the end of the course the direct relation between their pedagogical knowledge and TPACK which was initially significant became insignificant whereas the relations between content knowledge and TPACK became significant (Chai, Koh, Tsai, & Tan, 2011). These studies point to differences between pre-service and in-service experienced teachers in terms of each of the constructs and indicated a need to provide support in the different types of knowledge constructs to different groups. More in-depth qualitative studies to shed light on the epistemological nature of TPACK is needed (Koh et al., 2013). Findings from this case study will shed more light to it as it looks at one experienced mathematics teacher's knowledge constructs.

In determining whether TPACK was an entity by itself or a combination of the three pairs of knowledge constructs (PCK, TCK and TPK) Angeli and Valanides (2009) found that ICT-TPCK is a synthesised body of knowledge about ICT tools and their affordances, pedagogy, content, learners and context that enable topics that are difficult to be understood by learners or difficult to be represented by teachers, to be taught effectively with technology. Another study, on the other hand found there was a lack of knowledge about Web-related pedagogy among teachers and this was more pronounced among older and more experienced teachers (Lee and Tsai, 2010). This prompted the authors to differentiate it as a specific type of TPACK which they called TPCK-Web. In trying to make sense of *what* TPACK is developed by teachers, Niess, Ronau, Shafer, Driskell, Harper, Johnston et al. (2009) identified mathematics teachers going through five stages of developmental learning in their use of technology. They suggest Technological Knowledge (TK) as being developmentally integrated with Pedagogical Content Knowledge (PCK) through the process of recognition, acceptance, adaptation, exploration and advancement of technology use in the subject domain. These stages were defined as follows (Niess et al., 2009, p.9): *Recognising:* teachers are able to use the technology and recognise the alignment with mathematical content yet do not integrate the technology in the teaching and learning of mathematics; *Accepting*: teachers form favourable or unfavourable attitudes towards teaching and learning mathematics with the use of appropriate technology; *Adapting*: teachers engage in activities that lead to a choice to adopt or reject teaching and learning mathematics with an appropriate technology; *Exploring*: where teachers actively integrate teaching and learning of mathematics with an appropriate technology; *Advancing*: where teachers evaluate the results of the decision to integrate teaching and learning mathematics with appropriate technology.

This case study explores the knowledge constructs and developmental stage of the teacher through the TPACK framework. It seeks to determine its effect on task design and instruction. Students' perception of the efficacy of the Internet for mathematical learning was used as a means to triangulate the teacher's and students' perception of what learning occurred. It concludes with implications for professional development to further support teachers in their quest for TPACK.

METHOD

The Context

This case study was part of a broader study where the teacher participated in a survey on the use of the Internet for secondary mathematics teaching. From this preliminary questionnaire it was found that the teacher, Mr Z, had thirteen years of mathematics teaching experience and was a frequent user of the Internet and generic software such as Microsoft Excel. He had attended professional development on the use of the Internet where he 'learned how the Internet could be used by Maths Applications students in research' and received 'advice on where to find help applets to use in demonstrations to students'. Based on his use of the Internet in mathematics he was subsequently interviewed. During the interview he said:

> [A]t the moment I'm using the internet for an investigation into banking. I'm using a website from the Commonwealth Bank which is aimed for students … and they're doing a project, an investigation on borrowing money from the bank to buy a car and a holiday, and they use the Commonwealth Bank dollarsandsense website to first of all investigate some of the expenses and then after that they get to the various bank websites to see what interest rates and charges are involved, and from there they create a spreadsheet for all the calculations for their loans.

The subjects were the teacher (Mr Z) and twenty of his Year 11 students (second last year of secondary education in Australia) from a private school in South Australia as they used the Internet to complete this mathematics assessment task. Mr Z taught the Year 11 Business Mathematics class four lessons a week and used the computer laboratory for one of the lessons each week. The assessment task was to carry out an investigation to determine how much it would cost to buy a car or renovate a house or go on a holiday overseas, and to work out a budget for one of these based on an income after tax and a loan from a bank. Students were given a list of Web sites as examples to use in the assignment but were also permitted to access other sites to gather information for the assignment.

Data Collection Methods

A "mixed methods" approach (Creswell, 2002; Punch, 1998) was used. Both quantitative and qualitative methods were employed to ascertain how the teacher used the Internet in a mathematics assessment task and the students' perceptions of that approach. Data collection methods included an initial teacher interview prior to classroom observations, classroom observations, post-lesson student interviews and post lesson teacher interviews. A questionnaire survey on student attitudes to and perceptions of the use of the Internet in mathematics lessons was completed by students at the end of the observations. The following explains how each of the data collection methods helped answer the research question.

Initial Teacher Interview

This interview was conducted with the teacher after the preliminary survey when it was found that the teacher had made use of the internet in mathematics. This was a semi-structured interview (see Appendix 1) and key questions were asked during the interview. Questions 1, 2, 9 and 10 were designed to elicit an overview of the environment the respondent is in and to see if there was any connections between the environment and the extent the respondent uses the Internet. Questions 3, 4, 5 and 7 were intended to determine what discernible Internet-based teaching strategies the teacher used to teach Mathematics and the conditions for their use. Questions 6 and 8 related to teachers' beliefs and attitudes and were intended to gain understanding to determine the role teachers' beliefs and attitudes play in the teacher's choice of and implementation of strategies for teaching mathematics over the Internet.

Classroom Observations

In this study, classroom observation allowed the researcher to get an in-depth and holistic understanding of what was happening in a naturally occurring and complex environment like the classroom (Punch, 1998). Observations were conducted in three of the lessons in the computer room to gain an understanding of what the teacher and students do in this technology-based assessment. Classroom observations enabled the researcher to observe students' interactions with the computer as well as with the teacher and were documented via short written notes.

Post Lesson Teacher Interview

The teacher was asked a number of semi-structured questions after the completed series of lessons (see Appendix 2). This interview had dual purposes: firstly, it was to elicit additional information about the teacher's technological, pedagogical and content knowledge that was contextual (Questions 1-3, 6-7). Secondly, it was to determine the teacher's perception of students' response to the approach used (Questions 4 & 5).

Post Lesson Student Questionnaire

Whilst there were 20 students in the class only16 students present on the day completed a questionnaire on their perception about using the Internet for mathematics learning. The questions in this survey were part of a larger set of questions that was generated by the author and has an alpha internal reliability of 0.9238 (indicating the items are closely related as a group with an underlying construct). All items employed Likert-style response type with options ranging from SD (Strongly Disagree), D (Disagree), (U) Undecided, (A) Agree and (SA) Strongly Agree (Creswell, 2002). This corresponds to a five-point scale where 1= Strongly Disagree, 2= Disagree, 3= Undecided, 4= Agree and 5= Strongly Agree. The results, although non generalizable due to the small number, provided a general sense of this class's perceptions of the use of Internet in the series of lessons and helped triangulate data derived from the student interviews.

Post Lesson Student Interviews

In this paper, interview data from six students were used to highlight the findings as the author had identified them as being present in all the sessions and using the Internet extensively. The following semi-structured interview questions were intended to provide opportunities for some students to provide further elaborations that might enrich the quantitative data.

1) Did you like doing that lesson with the Internet? What did you like/not like? Why?
2) How has the Internet helped/not helped you in understanding that mathematics concept? How did it help/not help?
3) Did you face any difficulties?
4) Would you like your teacher to use the Internet again in future?

The purpose of the post lesson student questionnaire and interview was to ascertain whether there was a match between the teacher's perception about the use of the Internet and mathematical learning with students' perception of the use of the Internet in this assessment task. All interviews in this study were audiotaped and the recordings were transcribed. Pseudonyms have been used in this paper.

Data Analysis

Data from the student questionnaire were analysed in SPSS using descriptive statistics and frequency counts. The audio taped conversations with teachers and students were transcribed and open coding was carried out. The aim of open coding is to discover, name and categorise phenomena as well as to develop categories in terms of their properties and dimensions (Strauss and Corbin, 1990 cited in Denscombe, 1998). As more and more open coding is carried out on the interview transcripts, themes and relationships begin to emerge. In the initial open coding of data from the teacher interview transcripts, the researcher analysed the transcripts for instances where the intersecting knowledge constructs of pedagogical content knowledge, technological pedagogical knowledge and technological content knowledge as defined by Mishra and Koehler (2006) was evident. The presence and intersection of such knowledge constructs as set out by Koehler and Mishra's framework suggested the existence of the ultimate entity TPACK. Thus in the analysis of the data the researcher coded elements that showed semblance of current definitions of the knowledge constructs as set out by Schulman (1986) and Koehler and Mishra (2009) to see if it does culminate in TPACK. In this analysis, classroom observation data were not used to triangulate the teacher interviews because there was not much teaching happening in the computer classes. These data were instead triangulated against data from student interviews and student questionnaires. Reflections on these enabled meaning to be made (Denscombe, 1998) about this teachers' TPACK.

RESULTS AND DISCUSSION

Student Perceptions of the Internet for Learning Mathematics

Student Perceptions of the Internet Approach To the Task

Table 1 is a summary of students' perceptions to the Internet based task. In terms of being able to access data, although more than half of the students (53.3%) agreed that the Internet allowed them to gather material for their investigation more easily, only 37.5% of the students agreed that it made it easier to do the investigation in an area of their interest. A small percentage disagreed that the Internet helped them to gather materials for the investigation more easily (20 %) or in an area of their interest (25%). These might have been students who chose to actually go to the different places to obtain their data as this was a choice the teacher gave them. While slightly more than half the students (50.1%) indicated they liked being able to get real information from the Internet, a small percentage (18.8%) did not. While about a quarter of the students (25.1%) felt that learning mathematics with the Internet was a waste of time, 50% of the students agreed that doing the investigation on the Internet was better than doing it from the textbook. Even though the Internet presented authentic scenarios and information that students can relate to, only 25% feel that doing the investigation with the Internet will help them in life with about 31% being unsure if it will. More than a third of the students seem unsure of the benefits of the Internet as evidenced by their response of 'undecided' in most of the statements. Perhaps such open-ended authentic investigations can be set up in more structured manner which allowed students to reflect on what they have done with what they have learnt mathematically. This is a question for future study. Would teachers making such connections more explicit in their teaching make authentic scenarios more meaningful and stimulating for students?

Table 1. Students' Perception of A Directed Investigation on the Internet, n=16

Item	S D	D	U	A	SA
			% Response		
It is more fun to learn mathematics from the Internet than from a textbook	6.3	12.5	37.5	18.8	25.0
Learning mathematics with the Internet is a waste of time.	25.0	25.0	25.0	18.8	6.3
Doing the investigation on the Internet is better than doing it from the textbook.	6.3	18.8	25.0	37.5	12.5
I like being able to get real information from the Internet to do mathematics.	6.3	12.5	31.3	31.3	18.8
I feel stressed answering the questions on the Internet	12.5	37.5	25.0	18.8	6.3
The Internet makes it easier for me to do the investigation in an area of my interest.	12.5	12.5	37.5	25.0	12.5
Doing the mathematical investigation with the Internet will help me in life.	6.3	37.5	31.3	12.5	12.5
Writing up the investigation is easier with the Internet	12.5	12.5	31.3	25.0	12.5
Using the Internet allows me to gather material for my investigation more easily.	13.3	6.7	26.7	40.0	13.3

Note. SD= Strongly Disagree, D=Disagree, U= Undecided, A= Agree, SA= Strongly Agree

Students' Perceptions about the Internet Activity Contributing To Mathematics Learning

(a) Time saving

From the questionnaire responses, 20% of the students disagreed that using the Internet allowed them to gather material for their investigation more easily. This corresponded with the 24% who say that 'Learning mathematics with the Internet is a waste of time.' This could have been because they did not use the Internet to gather information due to a personal preference or some other reason. One student said she did not like doing it on the Internet "Because you can't talk to the person. Often when you're talking to the person face to face, you've got 'Why is this happening?' If the internet goes kaput you have to somehow fix it with the mouse and the keyboard…You can't ask questions...You're going to have to call them anyway". These comments might have been one of the reasons why about a fifth of the class feel negatively about the use of the Internet in learning mathematics or that this investigation on the Internet can help them in life. Some students saw the value of the Internet as it saves them from having to go to the banks for information thus saving them time and others thought it was better than books because of the amount of information there.

> Yeah it saves you time, you don't have to go out of your way, even if you're at the shops already, like you don't have to wait in a queue, you can just come home and go on the computer. (Bradley)
> I think the Internet has lots more info than having to look in the book … you can't always get everything in a book. (Zoe)

The responses above provide some of the possible reasons for the positive responses in the questionnaire to the question "Using the Internet allowed me to gather material for my investigation more easily". To elicit further insight, future studies could include questionnaire items that allow for more open ended responses.

(b) Modelled real life

When students were asked whether this was a good way to learn mathematics, they said it helped connect what they were learning in class with real life.

> Yeah it is, because we're basically learning how to do all these personal loans and stuff during class, and this really opens it up for the students, and it involves banks and it also teaches them about life as well as mathematics at the same time. (Katie)
> Yeah I guess the understanding about what happens in the real world would be an advantage because you're more aware of what happens in personal loans. (Geraldine)
> These responses gave further insight into why some of the students responded positively in the questionnaire item "I like being able to get real information from the Internet to do mathematics."
> When asked how they knew the calculations on the bank calculators were correct, some said that they had checked it or could work out the calculations on their spreadsheets.
> You've got to work it out in some cases. (John)
> I probably could, using formulas we've been given in maths at the present moment. (Geraldine)
> …because the websites would have made sure they were working. I could easily back it up, and make sure they had the right numbers. (Danielle)
> Geraldine also said she was able to use what she had learnt to double check on the accuracy of the loan calculators and when she found a discrepancy and realised she made an error. She explained
> Yes I did, because using that loan calculator, the comparing one, I realised that within the repayments, monthly, it included the annual fee . . . and in our spreadsheet we were supposed to include it again. . . (Geraldine)

While the learning of the mathematics was in an authentic context it was not obvious to some students that they were actually doing some verification with the bank calculators. One student (Katie) said 'You sort of go on the basis of the Internet, the Internet would always be right basically. . .' but apologetically added that she should have double-checked by doing her own calculations because '…that's what we've been taught in mathematics, like how to work out interest rates and stuff like that.' . Another student said she did not check it "… because the websites would have made sure they were working." These students' comments showed that the Internet activity with the bank calculators could have been easily overlooked as simply obtaining information from the online bank calculators instead of one of comparison with calculations from their own spreadsheets and understanding the mathematical reasoning behind the figures.

The findings above indicate that while students were familiar with the Internet and the Microsoft Excel software, their perceptions of the use of the Internet in terms of this approach for mathematics learning were mixed. Some regarded the approach as time saving and modelled real life, others were not convinced that it saved time or that they learnt mathematics through this approach.

Teacher's Knowledge

Teacher's General Internet Knowledge and Use – Technological Knowledge

In the initial interview, Mr Z elaborated on his frequent use of the Internet which he had indicated in the questionnaire. He commented he regularly looked for ideas in Internet forums such as the Maths Forum and other web sites and "then I adapted it to the course". Email communications with his students were common. Some students regularly asked questions and he would send them "topics for the test and the revision courses that they can do and …information sheets, examples of spreadsheets…". He explained that he structured his use of the Internet by booking the computer laboratories for every third lesson of his weekly classes for all year levels. He said "the internet hasn't been a focus of professional development" but that he had begun "some professional development…from the IT department ... to do with online courses". He believes the Internet gives students

More scope, and I think it allows them to sort of try and create their own understanding, … I give them all the same thing and they all had to just present an investigation, then they wouldn't learn as much as they have, surfing the sites and then they tend to talk about what their projects were about, so they've been able to tap into it…mostly from the internet. That's much more than I could give if I had to find it all myself.

He sees the Internet as providing an extension beyond himself that students can utilise to their advantage. He claimed his teaching style is more constructivist as he "do[es] like it when the students are able to find some materials and they're really working on it by themselves," This comment showed he values that the technology enabled the students to learn independently. This is also echoed in the following statement where he commented on how the Internet is a rich resource that can be accessed easily, quickly and from anywhere.

…for me it's useful in maths that's to do with financial maths and statistics…so rather than the students,…, spending a lot of time collecting primary data, which is not really what I want them to do because I want them to concentrate more on the analysis. So the internet is a very good source of data sets…on the website, they can go to the information that's there and be able to get their way around it, find out what they want much more quickly, and they can do that from home as well.

He regards the Internet as a place to go to access learning material such as animations that help explain concepts but for which he does not possess the skills or time to make. I don't have time to do that (animations) because I don’t have the skills, and it would take me too long to develop something like that. In any case, I think there are things on the internet that you can just tap into anyway, rather than finding the time to do it.

When asked what was the reason for his use of the Internet in this assessment task he said, “Basically what they’re trying to do is shop around, using the idea of shopping around on the internet …, and they’ve got to apply their skills, their mathematical skills, to help them with the shopping around, so the internet gives them the search information, and then they combine that with their mathematical skills to make a comparison, so which bank will give me the best loan”.

He was modelling for them a way to ‘shop around’ using the internet and their mathematics skills to compare, analyse and make decisions with the information obtained. The researcher observed that in all of the lessons in the computer classes, Mr Z did not teach the students but was roving and answering students’ questions.

Pedagogical Knowledge

Mr Z demonstrated pedagogical knowledge when he recognised the appropriateness of the project for students of that age.

> Yeah, and because it was tailored for students of their age, and they all like to dream about going on a holiday or having a car, it was something that engaged them.

His judgement about the site’s relevance was based on the knowledge that the Commonwealth Bank’s Dollars and sense website (www.dollarsandsense.com.au) was custom built for students in 14-21 years age group and his understanding about the developmental psychology of students in that age group. He also capitalized on students’ affinity to work on the computer.

> They’re enjoying using the computer anyway and it’s part of their culture anyway, it’s not something they don’t like doing.

He perceived that students at that age would enjoy doing work on the computer and the socio-cultural element in such a task thus demonstrating an understanding of the cognitive, social and developmental theories of learning that relates to his students and how to engage them.

Pedagogical Content Knowledge

Pedagogical content knowledge goes beyond knowledge of the subject matter to the dimension of subject matter knowledge for teaching (Shulman, 1986, p.9). It is having deep knowledge of the subject and knowing ways of representing the subject in a manner that makes it comprehensible to others.

> When asked what he hoped the students would gain from these series of lessons, he said, “I think the biggest thing is that in real life looking for a loan for something that you need to buy, that you would in real life shop around. If you were to buy a large item, like a car for example, you wouldn’t just go and buy it unless you had lots of money, you wouldn’t go and buy the first car you saw, you would shop around, and that involves judgement and estimation and analyzing things”.

Mr Z felt that by allowing the students to 'shop around' and comparing costs (different bank loans) he was giving then opportunities to make judgements, estimate and analyse and make connections with the content in Business Mathematics. He perceives that to make the content in Business Mathematics relevant he had to put it into a context which will make the learning of the concepts easier for students to grasp (Shulman, 1986).

Technological Content Knowledge

Technological Content Knowledge (TCK) refers to knowing how representations of the subject matter can be changed through use of the technology (Koehler & Mishra, 2009). Mr Z's technological content knowledge enabled him to see how the students could use the spreadsheet and the online calculators as tools to verify the accuracy of the bank calculator and as a means to explain what they have found.

> Well I suppose they were looking at a real bank Website, so it was something that was part of the real world, and in that sense the sorts of things that we'd be talking about in the classroom would have direct relevance to something in the real world. . . . Doing calculations in the classroom to do with the calculating of compound interest or something like that, when we were actually visiting the Website, they'll find things that would be relevant. . . .What they were encouraged to do was to use those calculators on the Website as an extension of their own explanation (about hidden costs).

He had suggested that students compare the calculations in the banks' online loan calculators with those they worked out in their Excel spreadsheet as a way to validate and model the mathematical calculations.

Technological Pedagogical Knowledge

Technological pedagogical knowledge is knowledge about the existence, components and capabilities of various technological tools as they are used in teaching and learning situations (Mishra & Koehler, 2006). His knowledge of technology and pedagogy enabled him to see where relevant technology should be used to speed up the process so students can better use the time to analyse and synthesise the results.

> …without the Internet you'll be on the telephone or going to the places to get the information you'll be spending much more time doing that than this other thing that I want them to do.

He noticed how technology can change learning environment and the engagement of students. Mr Z found them (as the author has) to be very focussed in their task.

> I think with the Website calculators they were focussed. Some of them were actually using them, because it was always very quiet.

Although the lessons were satisfactorily implemented he felt that it was not as focussed as it should be.

> I felt …that sometimes it was dragging, and . . . it needed to be a bit more focussed at times.

This comment revealed that Mr Z was evaluating the process and students' priorities and reflecting on what needed to change.

Technological Pedagogical and Content Knowledge

He clearly demonstrated aspects of the technological pedagogical and content knowledge when he highlighted the reasons and his beliefs on the efficacy of the Internet for teaching mathematics in this way. From this assignment a few of the students realised that there were hidden costs although it was difficult for them to see these costs unless they had compared the repayments from different banks. Mr Z facilitated this by providing them a site where they could compare repayments.

> They found it difficult to find out (about hidden costs). They did find a Website that compared lots of banks and that was quite useful. So that (the Cannex Website) was very helpful to them, and of course they had to try, in this task, to use their spread sheet skills as well, so there was quite a lot for them to do in terms of taking information from there to there and then constructing a spread sheet and …to analyse it, and this would be, for most of them, the first time that they've constructed a spread sheet like that, so it took quite a while.

Scaffolding the students in this way was a pedagogical skill that required understanding of the students' abilities and the cognitive overload (Ayres, 2006; Mayer and Moreno, 2003) that might be brought on by the multiplicity of tasks. This pedagogical insight was also evident when he required students to verify the search results from the bank calculators with the actual calculations using the formulas constructed on their spread-sheets.

> Well it was a requirement of the assessment task as well that they would construct their own spread sheets, so when they constructed their spread sheet they would come up with the same answers that the bank calculated...One or two feel that they came up with the same answer, but they all have to do the spread sheet, in theory, and that would mean that none of them just have accepted what it said on the Website without actually doing some mathematical work for themselves, and they have to print off formulas that they used in Excel, so they use Excel to do their actual calculations and they use formulas to do that.

By actually getting students to construct their own spreadsheet to verify the calculations from the calculators, Mr Z provided them alternative representations of the concepts that were being taught which showed evidence of his TPACK.

> I'm trying to get them to gather together information that we could make some useful comparison between the various banks, and then use their skills and calculations and spread-sheets to make a model of that, and to make comparisons from there, so they're working on their Websites to find, not just the interest rates, but the other details, like the annual fees that might be involved, and then that will help them to compare one offer from another. . . .

There was evidence his TPACK was at the exploring or advancing level (Neiss et al., 2009). He had planned and implemented the task and then reflected on how to guide the students to more learning using the technology.

> They sometimes spend too much time doing that part, wanting to know the cost of the actual journey for the holiday, some of these things I felt from the course point of view that wasn't as important as the next part of making a spreadsheet, the analyses and so on. . . I think I would probably do with a checkpoint list . . . I think it would help me pinpoint where I could help the students, somebody hadn't quite reached the point of deciding how much they were going to borrow from the bank…

These comments indicate the sentiments of a reflective practitioner (Schon, 1983) who felt the need to improve the way the learning was taking place. He felt that he should have monitored the progress of the students a bit better by having more check points and was evaluating the use of the technology and the amount of engagement and critical learning demonstrated by the students. His pedagogical expertise prompted him to say that he needed to shift students' focus on obtaining information to critically analysing the information and using it for further investigation and synthesis.

Discussion

To answer the research question 'To what extent is the teacher's TPACK evident when using the Internet' it is reasonable to conclude that Mr Z possesses technological knowledge (TK), pedagogical knowledge (PK), pedagogical content knowledge (PCK), technological pedagogical knowledge (TPK), technological content knowledge (TCK) and TPACK. This theoretically would have led to effective technology integration. To a certain extent this had been achieved in this class as students were found to be engaged and completed the assessment piece on time with the production of work as anticipated. However, despite having these successes, Mr Z was dissatisfied with the outcome of the lesson and commented on how he could improve the approach to include more time on analysis rather than giving students so much time to search the Internet.

Clearly, foremost in the teacher's consideration for the use of the Internet was the amount of computer time allocated to the class which was constrained by the infrastructure within the school. In his Computer Practice Framework (CPF), Twining (2002) called this 'quantity of time of computer use'. This determined the quantity of time used for computer supported teaching and learning. In this case study, the teacher had allocated 25 % of the learning time for computer use (one out of four lessons). However what was considered by the teacher as important was not so much this overall allocation of time but rather the purposeful use of this time with the computers. This relates to the academic learning time (ALT) where effective learning takes place. ALT was defined as ". . . that part of allocated time in which students are engaged with materials or activities related to the outcome measures that are being used and in which students experience a high success rate" (Berliner, 1987, p.101). The ultimate goal of any technology integration is that it will lead to effective teaching and/or learning. Berliner's definition of effectiveness is that the teacher is able to get most of his /her students to learn most of what they are supposed to learn. Therefore, an important predictor of effectiveness is the ALT that takes place in the classroom. This teacher's reflection indicated the need to specify an optimal search time which is neither too long or too short otherwise the goal of the lessons could be compromised. In this case study, the teacher conceded too much time was spent searching on the Internet.

The following discussion answers the second research question: 'To what extent are the learning goals met as perceived by students and teacher?' The focus of the teacher was not on the technology or building up the skills of the students in using the Internet but rather using the Internet as a learning tool to engage and motivate students in learning the practicalities of the mathematics they are learning. The Internet was used as a support tool to search for data as well as a transformational tool to enhance the learning of business mathematics through the use of real and simulated contexts. Hence the mode of use was envisaged as one of support as well as to transform learning (Twining, 2002). The teacher's intention was to prepare students with analytical and mathematical skills they can use in later life by implementing mathematical modelling in the structure of the assessment. The bank calculators were meant to be an accessory that students could use to see the link between real life mathematics and the mathematics they were learning. The results show that while the teacher aspired to extend the way students understand the mathematics through seeing the connections between mathematics in real life to what is learnt in the mathematics class, it was not immediately obvious to *some* of the students. What was lacking in the instructional strategy implemented by the teacher? Was there an opportunity for transformational learning that can be made more obvious to students?

The third research question 'What are the teacher's perceived TPACK needs?' is discussed here. Mr Z seems to have advanced technological knowledge as evidenced by the varied and regular use of the Internet. He would be what Neiss and colleagues (2009) proposed in their developmental model for TPACK as either at the '*exploring*' stage where teachers actively integrate teaching and learning of mathematics with an appropriate technology (in this case study he integrated the learning about compound interest with the bank calculators on the Internet and the electronic spreadsheet Microsoft Excel) or '*advancing*', where teachers evaluate the results of the decision to integrate teaching and learning mathematics with an appropriate technology (he reconsiders the amount of time he should be allocating for students to search on the Internet versus productive use of time for comparative analysis). He had pedagogical ideals and was sound in his content as he was able to design a task that related well to the content of Business Mathematics. However he admitted he had failed to provide the pedagogical support or momentum to enable the students to gain much from it when he reviewed that he needed to scaffold the students better by having more checkpoints. This seem to suggest that having an 'exploring' or 'advancing' TPACK does not guarantee that the intended learning outcomes will be accomplished as envisioned. The implementation process requires certain technological pedagogical knowledge (TPK) that might include anticipating students' inability to decide how much time and effort they should expend on a technology assisted task and taking steps to circumvent that. Is it possible then to say that teachers who embed technology effectively has another level of knowledge which is a combination of active integration and constant evaluation of their decision making them have another level beyond what Neiss et al. (2009) suggests. Could that level be termed as '*Accomplished'* stage of their TPACK?

This case study highlights the importance of the teacher's role in a technology-enriched mathematics classroom. For learning to be optimised, selecting a suitable scaffolding provided by the technology and ensuring teacher directed scaffolding in the form of a clear structure is imperative. It seems that the TPACK of this teacher can be further developed in the area of technological pedagogical knowledge (TPK). This case study demonstrates that possible areas of focus in TPK might be related to input on how to optimally use computer time (in this case study it is search time) and the transformative mode a teacher could potentially operate in. Development of this construct might mean a focus on specific TPK. While this result seem consistent with Koh et al.'s (2013) study where Technological Pedagogical Knowledge (TPK) was strongly related to TPACK formation, this study, in contrast to Koh et al.'s findings, found that the PCK of the teacher was an integral part of the teacher's TPACK. The focus on the teacher's TPACK and the constituent constructs in this paper was a deliberate attempt to study the 'weakest link' to see where a teacher can be better supported. In this case study that link has been identified.

CONCLUSION AND SUGGESTION

This case study illustrates the extent to which a teacher's technological pedagogical content knowledge (TPACK) of the Internet and Microsoft Excel software resulted in an enactment of technology use in a Business Mathematics classroom. While the pedagogical intent of the teacher was to use the Internet to save time and to discuss the mathematical content by comparing the calculations using bank calculators and the spreadsheet software, the data indicated that student perceptions of this approach were mixed. Although the study showed that the assessment goals were met and the Internet and Excel software were tools used to accomplish that, there was little evidence to suggest that students experienced a transformation in their mathematical learning. Management of the academic learning time was seen by the teacher as an area that needed to be reviewed and improved so that the important aspects of mathematical analysis and application take precedence over collecting data with the help of the Internet.

Whilst there are limitation to this study as it reports on one teacher's perceptions and his class' use of the Internet in Business Mathematics, the issue of effective use of academic learning time with technology is a problem that confronts many teachers. This study highlighted one specific aspect in the technological pedagogical knowledge construct, that is, teachers' management of academic learning time when using technology. Further research is required to identify what academic learning time with the Internet entails and how it can be optimised to enhance and transform learning. Future studies could also include more open-ended response questionnaire items to elicit further insight into students' perceptions of particular uses of the Internet.

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Appendix 1 Initial teacher interview

1) Can you tell me about the computer and Internet facilities that are available in your school and arrangements for their use?
2) How often do you use the Web for mathematics?
3) Can you describe how you usually use the Web in your teaching?
4) Do you think the Internet has helped the students in their mathematics learning?
5) Do you face any difficulties in incorporating this resource into your lessons?
   (a) How have you overcome these difficulties?
6) Why do you use the Web in mathematics?
7) Have you used any of the communication features on the Web such as teacher or student forums?
8) How would you describe your teaching style and has that style changed because of your use of the Internet?
9) How is the support level for the use of the Internet in mathematics teaching among your faculty members?
10) What professional development on the Internet have you had and what would you like to see?

Appendix 2 Post Lesson interview

1) What were you trying to achieve through these series of lessons with the Internet?
2) How do you think this approach will benefit the students?
3) Do you think the objectives of the lessons were achieved through the use of the Internet?
4) What was your perception of students' response to the use of the Internet in this lesson in terms of cognitive achievement of the lesson objective?
5) In terms of their affective aspects e.g. motivation, enthusiasm, sense of satisfaction, immediate attitude towards concept taught (e.g. hard to grasp, easy, understanding enhanced, etc.)
6) Did you encounter any difficulties in carrying out these lessons? Was equity an issue?
7) Would you do it any differently the next time? How?