# SUPPORTING TEACHERS IN DEVELOPING THEIR RiTPACK THROUGH USING *VIDEO CASES* IN AN ONLINE COURSE

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*Abstract: In order to help the participants on our online course engage critically with research to reflect on whether and how digital technology supports students' understanding and learning of mathematics, I proposed to trial the use of online video cases in the next presentation of this newly designed online course. In this chapter I will be reporting on trialling the use of video cases with the course participants and on the potential of using these videos with the aim of supporting the development of the participants' Research informed Teachers' Pedagogical Content Knowledge (RiTPACK) with a particular focus on how the digital environment supports students' mathematical work.*

*Keywords: TPACK, teachers as researchers, online teaching, digital technologies.*

## 1. INTRODUCTION

In this chapter I will report on a pedagogical intervention in our recently re-developed Masters level online course 'Digital Technologies for Mathematical Learning' which focuses on the teaching and learning of mathematics supported by digital technologies. The intervention is aimed at supporting the teachers enrolled on this course engage with research as they develop their TPACK.

*1.1 Overview of the chapter*

I start this chapter with a description of the content and organisation of the online course.. I then move to consider the pedagogical principles underlying the design of our online course, describing the rationale for our pedagogical innovation and intervention, namely the use of online video cases. The latter part of this chapter introduces a theoretical framework adapted from the literature in order to account for the course participants' learning as they started experimenting with using the new technology in their teaching practices and linking it with the theoretical and research knowledge base of the course. Finally, a case study is presented, together with the methods I employed in collecting and analysing of the data collected. A discussion which accounts for the learning and engagement with research of one of the participants on the course and a brief conclusion end this chapter.

In this chapter, I will be referring to the teachers enrolled on our online course as *participants*, while *students* will be used to refer to students in schools.

## 2. CONTEXT AND COURSE DESCRIPTION

There are two e-learning aspects of this Masters level course: 1. its online delivery and 2. the e-focus of the course itself, consisting of i) familiarisation of the participants (practicing or prospective mathematics teachers) with a wide range of digital tools and resources (graph plotters, dynamic geometry environments, statistical software, fully interactive online packages) and ii) critical reflection on the implications of using such tools in the learning and teaching of mathematics at secondary school level (11-18 years old students).

The main aim of this course is to encourage participants to reflect critically on the potential and limitations of digital technologies for the learning and teaching of mathematics by

providing opportunities for participants to apply knowledge of relevant research and theory to their professional contexts.

### *2.1. Course curriculum and organisation*

The course is taught online, with participants being given a series of tasks over a ten-week period. The curriculum for this course is divided into three themed sections: Visualising, Generalising and Expressing, and Modelling, with each theme lasting for three weeks.

During each of the themed sections, the course curriculum is arranged into a series of short tasks that culminate in the main task of designing and trialling a learning activity relevant to each theme. These short weekly tasks are signposted on the virtual learning environment of the course (Moodle) at the beginning of each week and include *offline tasks* such as: familiarisation with a piece of software and example problems using specific software; designing of a maths activity using the specific digital environment; trialling out the activity with students or other learners and reflecting on the learning episodes. There are also *online tasks* such as: engaging with the ideas in the key readings; reading one of the essential reading articles and write a response about the points agreed or disagreed with from the article; contribution to online discussion forums with written observations on views and perspectives of fellow participants. Each theme ends in an activity week for which participants are required to: choose a software tool relevant to the theme, design a learning activity using features of good practice identified from the literature, use the activity they designed with students and analyse its implementation through engagement with research and the ideas assimilated from the literature reviewed to evaluate and justify the implications of using digital technology for students' learning. In each theme, at least one task will form the basis of an online group discussion. The tutors also contribute to these discussions, with the aim of encouraging informed reflection and raising critical awareness of and supporting engagement with the research literature.

*2.2 Theoretical background: pedagogical underpinnings of our online course*

The design of this course has been influenced by the Technological Pedagogical Content Knowledge (TPACK) framework (Mishra & Koehler, 2006) which attempts to describe the body of knowledge and skills needed by a teacher for effective pedagogical practice in a technology enhanced learning and teaching environment. The authors proposed that a teacher's professional knowledge base *for teaching with the new technology* should include a type of flexible knowledge needed to successfully integrate technology into teaching, informed by and borne out of the interaction of three essential bodies of knowledge: content, pedagogy and technology. Drawing on the work of Koehler & Mishra (2008), Mishra & Koehler ( 2006) and Schmidt et al. (2009), Otrel-Cass, K., Khoo, E., & Cowie, B. (2012) described the TPACK as the intersectional relationship of six components as follows (see Table 1 below):

Table 1: TPACK components

| TPACK Components | Component Descriptors |
|---|---|
| TK or technological knowledge | Understanding about any kind of technological tool |
| CK or content knowledge | What is known about a given subject |
| PK or pedagogical knowledge | Teaching methods and processes |
| PCK or pedagogical content knowledge | Pedagogy specific to a particular subject area or content |
| TCK or technological content knowledge | What is known about a technology's affordance to represent or enhance content |
| TPK or technological pedagogical knowledge | Understanding of how technology may support particular teaching approaches |

TPACK has been used by many researchers, as this frame offers a helpful way to conceptualize what knowledge teachers need in order to integrate technology into their teaching practice, leaving the specifics of what lies in each circle to disciplinary researchers.

The participants on our course, either practicing or prospective mathematics teachers, bring with them a well-developed or developing PACK (pedagogical and content knowledge base).

When designing our course, I planned for opportunities for the participants to familiarise themselves with key types of digital technologies for learning mathematics, at the same time learning to appreciate the rationales and pedagogic strategies associated with these digital technologies for learning mathematics, thus facilitating the development of their **T**PACK.

*2.3 Course evaluation and reflections*

While the participating teachers enrolled on the first presentation of this online course reported development of their TPACK knowledge (as exemplified later in this chapter through a case study), writing about such experiences (as part of their contributions to online forum discussions, as well as part of written tasks and final assignment for this course) and applying the ideas encountered in the key readings in the particular learning context under scrutiny was a challenge.

Research acknowledges that 'novice' (to new practices) teachers 'see' less of the complexity of classroom events than do experienced teacher (Yadav & Koehler, 2007). I too realized that the participants on our course often failed to make explicit the connection of their 'research-based' learning with the particular instances of digital technology use in their practices which they were reporting.

I noticed for example, that during the weekly online discussions the participants provided narratives of their own learning or classroom based experiences with the new technology; these entries did indeed generate activity on the online forum discussions, but the narratives were mainly about 'what happened'. While this background knowledge was needed in order to comprehend what the learning episode was about, the written format of these asynchronously shared experiences proved to be mainly descriptive, hence time consuming, meaning that the participants rarely reached as far as engaging themselves explicitly with the research and

analyse ‘why that happened’, i.e. how their students’ mathematical work was affected by the use of the new technology.

Similarly, for their end of course assignment, the participants were expected to describe, analyse and interpret students’ experiences of doing maths with digital technology. The analysis of their written assignments provided us with a clear evidence that the participants found challenging to move beyond description of the learning episodes.

As a tutor, I came to realize that what was needed were opportunities for the participants to engage with analyzing and describing of learning early on in the delivery of the course. I also came to realise that the participants would benefit from shared learning episodes, as this would remove the need for a detailed description of ‘what happened’, instead allowing participants and tutors to focus on the analysis and interpretation of the learning of mathematics when technology was being used. These reflections led to consideration of a pedagogical intervention in the next presentation of the course, namely providing participants with ‘video cases’ of students’ doing mathematics with digital technology, with the potential to act as a catalyst in generating discussions and reflections focussed on the analysis and interpretation of the learning taking place.

## 3. THE STUDY

For the new presentation of the course (starting in January 2016), my intention was also to address Leat, Lofthouse and Reid (2014) call for the need to develop ‘teachers as researchers’. They acknowledge that (worldwide) the relationship teachers have with research is passive, that teachers may or may not choose to use it in their practice. Through the pedagogical intervention mentioned above, my intention was to support the participants in making their conversations more grounded in actual events, more insightful, and more resistant to oversimplifications, thus scaffolding our participants’ learning towards more active engagement in undertaking enquiry themselves, which ultimately will benefit their students.

I thus adapted Mishra & Koehler's (2006) TPACK frame to account for the participants' learning as they started experimenting with using the new technology in their teaching practices and linking it with the theoretical and research knowledge base of the course (Figure 1). I refer to this frame as teachers' Research informed Technological Pedagogical Content Knowledge (RiTPACK – my own acronym for this frame).

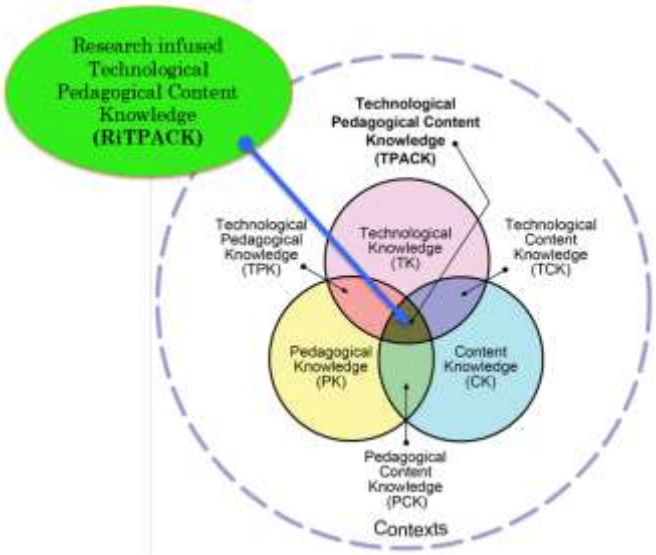


Figure 1: RiTPACK frame

Learning from my reflection on the first presentation of the course, I decided to provide the participants with *shared episodes* of students' doing mathematics with digital technology and support them in critically analysing and interpreting these episodes by engaging with and making connections with the theory and research they were reading.

Guided by Van Es and Sherin's (2002) study, I considered the use of video cases to provide the participants with a shared learning episode to analyse. Video cases have been used by several mathematics educators and researchers in order to help teachers focus on students' learning and on teachers' decisions made in lessons. Van Es and Sherin (2002) proposed that videos could be effective tools in helping teachers develop their ability to notice and interpret classroom interactions. Van den Berg (2001) highlights another the potential of using videos,

namely that they enable teacher educators to prompt the students to watch for specific elements when viewing a video, thus compelling the teachers to look more deeply than they might otherwise have done.

### *3.1 The aims of the study*

Thus, the aims of this study were to pilot the use of video cases and investigate whether and how this intervention supports and contributes to the development of the participants' RiTPACK, with a particular focus on how the digital environment supports students' mathematical work. My hypotheses was that through such an intervention the participants on the course will be supported in the development of their skills of noticing significant episodes when observing students' doing matehmatics with the new technology, which they would then analyse and interpret by engaging with the theory and research, with a long term view of preparing them to make informed decisions about use of digital technology that will benefit their students' learning.

### *3.2 Using video cases – a brief review of literature*

A search for resources such as Teachers TV, a website which provides video and support materials for those who work in education in the United Kingdom, including teachers, teacher trainers, student teachers and support staff failed to identify similar resources with a focus on using digital tools in mathematics lessons. For this reason, in order to support the participants' development of TPACK through reflecting on how the digital environment could support participants' mathematical work, I created and used online video cases in the new presentation of the course. I planned for and recorded a number of videos featuring students working

through mathematics activities in a digital environment, referred to as video cases in this chapter.

Of the many features of videos well documented in literature (Calandra et al, 2009, Van Es & Sherin, 2002), I mention here the capacity of a video to be paused, rewound, replayed many times in order for the viewer to focus specifically on segments of the videos selected strategically for their significance to the viewer, based on a particular goal (e.g. how the students' learning benefitted (or not) from doing mathematics in a digital environment). The design of the video case was informed by suggestions made by researchers (Van Es & Sherin, 2002) that the use of video clips could assist users to shift their attention away from the teachers, the classroom events and evaluating the teaching and learning, and focus it instead onto students' work. Through using a video, teachers can be supported to make tacit ideas explicit because "the process of making images encourages participants to consider why it is that the moment captured on film is important to them" (Liebenberg, 2009, p. 441)

In this research study, the video cases produced are recordings of the work of a pair of students, narrowing the focus of observation on the particular pedagogical activity of noticing significant episodes and analysing students' learning. The video cases produced for this online course features two Year 8 students, Tim and Tom (pseudonyms), both age 12, attending two different secondary schools in a large city in the UK. Since it was very important what the students did with the digital environment provided, a screencast video-recording software was used to enable video recording of students' on-screen work as well as an audio recording of any student-student interactions while working through the mathematics activity.

*3.2 Description of our video cases*

The following four short videos were produced:

| **Video Case 1** (3min) | **Video Case 2** (8min) | **Video Case 3 Part A** (1min) | **Video Case 3 Part B** (6min) |
|---|---|---|---|
| *Straight line graphs* | *More straight line graphs* | *Mid-points in a quadrilateral* | *Mid-points in a quadrilateral* |
| Plotting points *in a symbolic and graphical environment* that lie on straight lines of given equations. | Finding the equations of straight line graphs already plotted *in a symbolic and graphical environment*. | Recording of students' work while investigating the nature of the quadrilateral made by joining up the mid-points in a quadrilateral. | Recording of students' work while investigating *in a dynamic geometry environment* the nature of the quadrilateral made by joining up the mid-points in a quadrilateral. |

Figure 2 below is an example of what the video cases look like, together with some explanations of the areas of the video screen that participants should pay particular attention to. The video case show the boys (video of their faces) talk through the activities (audio recorded) as they use a digital environment to do some mathematics (their on-screen activity being captured, too). The boys were invited to work independently from a teacher. They were encouraged to talk through and to each other when working towards the solution to the mathematical activities they were presented with. Once the recordings were edited by the tutor, the short video cases (not longer than 10 min each) were uploaded online.

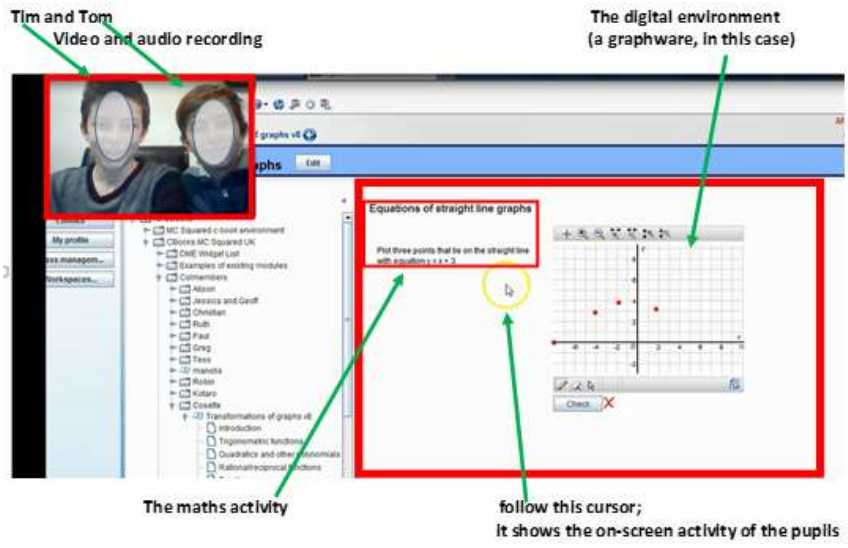

Figure 2: A screen shot from Video Case 1

The ethical dimension of creating and using these video cases was considered thoroughly. A review of some of the literature on the use of videos raised the researcher's awareness of the ethical considerations when images, video or audio recordings are taken, then posting them online (Flewitt, 2005). Permission to use the videos was sought through students and parents' consent, where my (the researcher)'s intention on how to use the video material and for what purposes was clearly explained.

*3.4 Piloting the use of video cases*

During the second presentation of this online course in (Spring 2016), I trialled the use of video cases for one of the three themes of the course, namely Theme A: Visualising. For this theme that spread over weeks 1 to 4 of the course, the course participants explored the value of access to multiple representations enabled by the digital technology in terms of the potential to facilitate learners' understanding of various areas of mathematics. The participants were expected to familiarise themselves with multiple representation software (such as graphing packages and dynamic geometry software, thus developing their TK – technological knowledge and skills) and experience for themselves the potential and limitations of these applications (contributing to development of their TCK - knowledge and skills concerning the combination of mathematics and the use of technology) in facilitating learners' understanding of the concepts and properties associated with functions and their graphical and symbolic representations and in promoting spatial and geometrical reasoning in mathematics (hence informing their TPK - knowledge and skills concerning the combination of mathematics and didactics of mathematics) (Mishra & Koehler, 2006). Two weeks into studying for Theme A: Visualising, for the end of theme task, the participants were asked to reflect critically on the

implications of using digital technology in the learning and teaching of mathematics. In designing the end of theme task, the participants were invited to strategically select particular sequences of the uploaded video cases that were significant to them and write their reflections on how the students' learning had been affected by doing mathematics in a digital environment. By choosing to focus on specific parts of the chosen video(s), the participants were invited to explain their new thinking and insights through engagement with research and ideas assimilated from the literature reviewed (the key course readings) in order to evaluate and justify the implications of using digital technology for the students' learning as portrayed by the video cases.

Researchers (e.g., Van Es & Sherin , 2002) wrote about the benefits of using videos in teacher education programs. It has been reported that participants who have the opportunities to use video write longer, with more evidence based comments about their teaching than those who did not have access to video, who tend to write more about classroom management issues and interpersonal relationships.

The tutors on the course provided scaffolding for the participants by modelling engagement with research and theory when analysing learning episodes of the video cases. For example, the tutor leading Theme A (also the author of this chapter) herself exemplified how she selected episodes in one of the video cases, how she annotated the video to focus on specific aspects of students' interactions with the digital tools which were significant to conceptual understanding of the mathematics under scrutiny and how she then analysed and interpreted students' learning, with annotations and explicit links to research and theory. A forum discussion of the 'model' upload followed, to further sensitivities and increase the participants' awareness of the analysis and interpretation of the learning and of the need to be explicit in making connections between research & theory reviewed and their observations of the students' learning/activities in these videos. They were made aware of the expectations of engaging with the literature

reviewed to support and back up claims such as 'all students understood', 'ICT helped', 'all learned', etc otherwise made by participants in our course in the previous year.

The participants were invited to watch the short video cases, then pause and reflect on how and in what ways the digital technology together with the mathematics tasks designed supported students' learning. Taking van den Berg (2001)'s suggestion into account, I too guided the participants to attend to the more sophisticated and less obvious aspects of doing mathematics through using the digital technology. In this respect, further scaffolding was provided to the participants with a number of guiding prompt questions while watching the videos: What would you consider as the benefits/limitations of using digital technology in this mathematics task, compared to a similar mathematics task but in a non-technology environment? What representations of this concept are facilitated by doing this activity in a digital environment? How did the students employed the digital environment to investigate the mathematics task and why? How did the design of the task support the students' consolidation of and extension of their knowledge about the mathematics concept/topic?

The participants written accounts of the end of theme task were shared online, hence shifting the focus of their online communications about each others' accounts of the learning in the *shared* episodes from the 'what happened' to their analysis and interpretation of 'the how and the why' supported by their own engagement with the key readings of the course. In the online learning environment of this course, there were opportunities for asynchronous contributions from all the participants. They were encouraged to engage with and learn from each other's contributions by watching the significant episodes each of them selected and then read about each other's analysis and interpretation. They could then reflect at their own pace on how each of them used the ideas assimilated from the key readings together with their personal knowledge and experiences in order to evaluate and justify how the boys' learning of mathematics benefitted from using digital technology. One participant's contribution to the

forum discussion illustrates how she benefited from reading accounts of learning episodes that may be different to your own interpretation *"Thanks for your comments, Mark. I have also read your written work and I appreciated your suggestion that teachers might have made students explore different quadrilaterals and discuss about the new construct. That was a really good opportunity for us to watch the videos which simulate a real teaching situation and to identify key points about them. I too felt lucky being able to access my friends' opinions."* (Dina's contribution, week 4, forum discussion)

## 4. PARTICIPANTS AND DATA SOURCES

All the participants (16) on our second presentation of the online course have agreed for their written contributions to be used as data for this research study. They constituted a convenience sample for researching whether and how the pedagogical intervention supported and contributed to the development of the participants' RiTPACK, with a particular focus on how the digital environment supports students' mathematical work. Gray (2014) notes that research that "… tries to understand what is happening … explores the personal construction of the individual's world [and] studies individuals … using small samples researched in depth or over time" (p. 12). Miles et al. (2013) in Gray (2014, p. 174) advise the selection of information-rich cases which can be studied in depth. For this reason, in this chapter the qualitative data collected and analysed for the purpose of the study reported in this chapter consisted of one participant' online contributions throughout Theme A of the course, his analysis and interpretation of the chosen episodes from the four video cases and his final assignment for this course; the assignment documented the participant'spersonal development of a mathematical idea or topic based on their exploration of digital technology and reflection on their experiences of designing and trialling the use of the activity with learners.

# 5. DATA ANALYSIS

The data were analysed using the RiTPACK lens. The conceptual framework structured what I noticed and paid attention to and took as important in the analysis of the data collected. My goal was to describe the development of the participants' TPACK components, with a particular focus on how the digital environment supports students' mathematical work, and to find evidence of them engaging with the theoretical and research knowledge base of the course when analysing and interpreting their accounts of students' learning.

Simon & Tsur (1999) talked extensively about *the generation of accounts of teachers' practice* as an attempt to understand teachers' current practices in a way that accounts for aspects of practice that are of theoretical importance, using conceptual frameworks developed in the research community. They characterised their methodology as "explaining the teacher's perspective from the researchers' perspectives" (ibid., p.254) and it was developed as an alternative to both deficit studies where the principal focus is on what teachers lack, do not know or are unable to do, and teachers' own accounts of their practice.

The RiTPACK lens also enabled me to identify in participants' written contributions explicit instances of where and how their analysis and interpretation of the mathematical learning was informed by theory and research.

Thus the evaluation of the pedagogical intervention of this study consists in analysing the developing 'quality' of a variety of the written contributions of the participants throughout the delivery of this course, where quality was evidenced in the levels of development of participants' engagement with the theoretical and research knowledge base of this course to analyse and interpret students' learning. In the following, I will be reporting on one participant (Mark – pseudonym)'s trajectory towards the development of his RiTPACK.

*5.1 The case of Mark*

Prior to the start of the course, all the participants on this course were asked to submit a short piece of writing about the digital technology use in their own learning and teaching of mathematics. By sharing these writings online, the participants were thus encouraged to get to know each other's backgrounds and experiences with the new technology.

Week 1 Mark, an experienced mathematics teacher, expressed his own views about the potential of digital technology: *Much technology used inappropriately simply does the same thing as non-technology, but used well [it] has the ability to add significant value* (forum discussion, week 2), with no further exemplification of his claim. Prior to his enrolment on the course, Mark had invested into developing his TK (technology knowledge): *My own experiences with technology is that I have spent a considerable amount of time in developing my knowledge and getting to know systems, to the point that I would probably have got better student outcomes by doing something else* (forum discussion, week 1), and at the start of the course he expressed his hopes that *I am getting to the point of pay off.*

Mark's writing at this stage is descriptive, drawing from his own experience with digital technology prior to starting the course.

Week 2 In week 1 of the online course, the participants were introduced to some key readings aimed at raising their awareness of the TPACK literature. In a written task at the end of the week 2 of this course, the participants were asked to describe their own TPACK components, namely knowledge, skills, and experiences on using the digital technology in their own mathematics learning and in their teaching, by exemplifying them with specific instances from their practices. Like most of the other participants on this course, Mark did not illustrate any of the claims about the development of his TPACK components with specific examples from his own experience with digital technology or from his own classroom practice. Instead,

his writing consisted of assertions about digital technology use in doing mathematics, without being clear if they were inferred from his practice or if they were just personal opinions, without empirical evidence. For example, Mark remarks that *Computer system is engaging. It allows participants to experience a variable by dynamically changing it and seeing the results "what is the same, what is different"* (forum contribution, MarkTPACKstory, week 2) which could otherwise be an indicator of his TCK. Referring specifically to his TPK, Mark envisaged his role in *show*[ing] *students what actually happens using dynamic functionality; instantaneous graphing and tabulating of results of expression allows for students to see the effect of a varying variable in these forms* (forum contribution, MarkTPACKstory, week 2). In his writing, there is evidence that his own awareness of how digital tools allow for the *interplay between representations dynamically* (an indicator of his TCK) influenced his view of how digital technologies could be used to support his students' learning *by seeing the same thing in different ways* and by *promoting thinking through questioning on predicting potential changes* (an indicator of his TPK) (forum contribution, MarkTPACKstory, week 2).

Mark's writing at this stage is a mix of descriptions and claims about learning, but with no evidence that connects the claims to specific events from either his experience or his practice.

Week 3 For the following week of this course (week 3), the participants themselves explored the value of access to multiple representations in terms of the potential to facilitate students' understanding of various areas of mathematics. They were asked to use a piece of symbolic and graphical representation software to investigate how the parameters in the general form of a quadratic equation were related to the graphical representation of the equation and share reflections on their own learning experiences. In his online entry, Mark comments on the importance of and the need for creating *many images to construct relationships that will facilitate visualisation and reasoning. This is where the technology is powerful in facilitating the creation of many images rapidly in order to focus participants on the connections between*

*them. Technology is also engaging and provides a change from the "normal"* (forum contribution, week 3). This is a big claim about the potential of digital technology, indicating his knowledge of TCK and TPK, but with no specific reference to the actual mathematics investigation he carried out, nor with an explicit insight into how it benefitted his own investigation of the task. Similarly, when asked to summarise his reflections on the learning opportunities facilitated by the use of a dynamic geometry software, Mark's writing provides evidence of his engagement with the key course readings (RiT): *The added value from the dynamic nature is how variance can be shown and more complex mental images can be created in participants' minds since they will see multiple images of the same problem. This can only enhance participants understanding and engagement (from Laborde, 2005)* (forum contribution, week 3), but he fails to link the research knowledge base of the course with his own experience when using the dynamic geometry software. At this stage, there is evidence that Mark's writing is descriptive and with some attempts to draw on the key readings, but this is not done explicitly.

While I wanted Mark and the other participants to continue to engage with research through using the ideas assimilated from the literature reviewed, I wanted to support them in noticing and interpreting students' learning when doing mathematics in a digital technology environment, by focusing on not only on 'what is actually happening' but also on 'how and why'. The video cases were introduced and tutor's modelling of analysis of an episode of students' learning was shared with the participants.

Week 4 For the end of theme task, Mark selected an episode from a video showing Tim and Tom working together to find the equation of two straight line graphs intersecting each other at a point. The significant episode he selected 'starts' at the point when the boys typed in a partially correct but incomplete equation of one of the two straight line graphs. Mark comments on how the feedback from the dynamic software *exposed* [the boys] *to a*

*misconception when the technology shows them the graph of y=4x* [which] *is different from the graph they are trying to define. Here they are able to quickly alter their incorrect conjecture as a result of timely response from the technology. Additionally, rather than just being told they are wrong and, as a result of the technology showing them the graph of their conjectured function* [the inputted equation] *beside the target function, they see that the coefficient of x is related to the steepness* [of the straight line graph]. *They both alter their conjecture fluidly and add clarity to their visualisation of the situation. Mariottii and Pesci (1994) cited in Elliot (1998) say that visualisation occurs when 'thinking is spontaneously accompanied and supported by images'.* (End of Theme A task, week 4). I see here a detailed description of the learning episode selected. Mark explains what the boys are doing, at the same time connecting his interpretation of the boys' actions with research and literature in an attempt to justify his evaluation of how the boys' learning benefitted from using the digital environment (an indicator of his RiTPK). Mark goes on to notice that the boys *add another image to the "family" of images.* Through doing so, *This connection between the coefficient of x and the gradient is again confirmed when their next conjecture of y = 2x-4 turns out to be too steep again, so they correctly reason that they need to reduce the coefficient of x again* (End of Theme A task, week 4). When analysing this observation of pupils' actions he draws on his PCK about pupils' learning of this topic, which he then links to the specificity of the digital technology environment, by explicitly making connections to *Solano and Presmeg (1995) cited in Elliot (1998)* [who] *see visualisation as 'the relationship between images'* to explain the boys' actions of using the software to sketch straight line graphs of equations inputted by them and improve their equations based on the feedback from the software (an indicator of his RiTPACK). He then explains how each time the feedback scaffolds the boys' learning *in order to visualise there is a need to create many images to construct relationships that will facilitate visualisation and reasoning* and concludes that the boys did benefit from the digital

environment as *in this thinking process another image is added to their visual understanding and they gain further clarity* (End of Theme A task, week 4).

End of course assignment In his end of course assignment, Mark describes one of his students' work with a dynamic geometry software: *Student 2, at the end of Task 3* [which Mark designed for his final assignment], *when asked about his understanding of Thales theorem said "I can actually see it". This implies that during the tasks he gained a clear visual picture of the Theorem, which he did not have before. The student's reference to being able to "see" the Theorem seems to link closely with the research on visualisation for understanding* (End of course assignment). In his assignment, Mark's RiTPACK is made visible through his explanation of how his review of the literature on visualization influenced his design of the student Task 3: *In Geometric Visualisations, visualisation is when students can perceive a family of images with the same "geometric make-up" (Healy, 2000, p. 111). The ability to make connections between images facilitates reasoning (Jones, 2001) and is therefore critical in forming and proving new mathematical ideas that could later become theorems once proven. Visual methods of solution complement and provide an alternative to a traditional symbolic approach used in mathematics (Cunningham in Elliot et al, 2000).*

At this stage, Mark's writing is concerned with analysis and interpretation by drawing consistently on the literature and research and he even begins to offer pedagogical solutions based on his interpretations: *This suggests that students will benefit from approaching a problem in both a visual and traditional symbolic way and each will add something to the students' understanding* (End of course assignment) providing further evidence of the development of Mark's RiTPACK.

## 6. IMPLICATIONS AND CONCLUSIONS

The primary focus in this research study was the development of one of four aspects of the participants' RiTPCK, namely their knowledge of students' learning with technology through a pedagogical intervention. The analysis of Mark's written contributions over the first four weeks of this course indicated that Mark's RiTPACK was developing. While there is evidence that Mark started developing his TPACK and engaged with research right from the start of the course, the connection between these two aspects of his learning on the course was not established until later on in the course (weeks 3 and 4). There is evidence in his end of course assignment that the his prior engagement with the video cases (the pedagogical intervention in week 4) supported Mark in writing about and reflecting on specific instances where the digital technology supported students' thinking about and learning of mathematics, which he analysed and interpreted through engaging with the key readings (Ri) and connecting it with his personal knowledge and experience (TPACK).

Through this pedagogical intervention, the intention was to support Mark (as well as all the other participants on the course) become more actively engaged with the research and knowledge base of this course rather than just ingurgitating messages that 'experts' put forward/ proclaim about the potential of digital technology.

From the work presented here, I propose that through using video cases teacher educators could support participants in Masters level courses learn how to critically analyse practice. This is significant for several reasons. Firstly, the intervention I designed was brief, consisting of an intervention early on in the delivery of the course (week 4), at a time when the participants have started developing their TPACK (specific to Theme A) and started engaging with the key readings of the course. Reflections on previous presentations of the course provided clear evidence that the participants found it challenging to apply the ideas encountered in the key readings when reflecting on students' learning with digital technology. Through tutor

modelling on how to engage with research and theory when analysing learning episodes of the video cases, I raised the participants' awareness of actively engaging with theory and research and supported them in how to make this explicit in their writing. This was an important aspect of the intervention, as in an online course writing is the only means of communication when teaching and in peer collaboration.

Secondly, the video cases provided the participants with shared learning episodes to analyse which together with sharing their written accounts supported further the participants in critically engaging with (different interpretations) of 'the how and the why' and where each participant's analysis and interpretation was supported by the research and theory reviewed.

Another dimension of this research study was the advance of the RiTPACK theoretical framework. As exemplified through Mark's case study, RiTPACK framework can provide an analytical and yet pragmatic tool in suporting teacher educators raise the critical awareness needed for teachers to reflect on their practices.

REFERENCES

Crisan, C., Geraniou, E. & Mavrikis, M. (2015). The emerging pedagogy of an on-line module, UCL Teaching and Learning Conference 2015, London.

Calandra, B., Brantley-Dias, L., Lee, J.K. (2009). Using video editing to cultivate novice teachers' practice. *Journal of Research on Technology in Education 42*(1), 73-94.

Elliot, S. (1998). Visualisation and Using Technology in A Level Mathematics, in Rowland, T. and C. Morgan, *Proceedings of the BSRLM, 18*(2).

Laborde, C. (2005). Robust and soft constructions: Two sides of the use of dynamic geometry environments. In *Proceedings of the 10th Asian technology conference in mathematics* (pp. 22-35).

Leat, D., Lofthouse, R. & Reid, A. (2014). Chapter 7: Teachers' views: perspectives on research engagement , Research and Teacher Education: The BERS-RSA Inquiry.

Liebenberg, L. (2009). The visual image as discussion point: Increasing validity in boundary crossing research. *Qualitative Research, 9*(4), 441–467.

Mishra, P., & Koehler, M. J. (2006). Technological Pedagogical Content Knowledge: A new framework for teacher knowledge. *Teachers College Record*, *108*(6), 1017-1054.

Otrel-Cass, K., Khoo, E., & Cowie, B. (2012). Scaffolding with and through Videos: An Example of ICT-TPACK. Contemporary Issues in Technology and Teacher Education, *12*(4), 369-390.

Pepin, B., Gueudet, G. & Trouche, L. (2013). Re-sourcing teachers' work and interaction: a collective perspective on resources design, their use and transformation. *ZDM-The International Journal of Mathematics Education. 45*(7), 929-943.

Stephenson, J. (2001). Teaching & Learning Online: Pedagogies for New Technologies. Stylus Publishing, Inc., 22883 Quicksilver Dr., Sterling, VA 20166-2012.

Van den Berg, E. (2001). An exploration of the use of multimedia cases as a reflective tool in teacher education. *Research in Science Education,* 31. Online: http://dx.doi.org/10.1023/A:1013193111324.

Van Es, E., & Sherin, M. (2002). Learning to notice: Scaffolding new teachers' interpretations of classroom interactions. *Journal of Technology and Teacher Education, 10*(4), 571-596.

Yadav, A., & Koehler, M. (2007). The role of epistemological beliefs in preservice teachers' interpretation of video cases of early-grade literacy instruction. *Journal of Technology and Teacher Education, 15*(3), 335-361.