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, we propose to trial the use of ***online video cases*** *in the next presentation of our newly designed online course. In this chapter we 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 we 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 teachers' engagement with research as they develop theory TPACK.

A description of the content and organisation of this online course follows this introduction, followed by a discussion of the pedagogical principles underlying the design of our online course. This is followed by a section describing the rationale for out pedagogical innovation and intervention, namely our use of online video cases. The description of the theoretical framework follows, together with the methods we employed in collecting and analyseing our data. Finally, a case studyis presented, together with a discussion and a brief conclusion. In this chapter, we will be referring to the students enrolled on our online course as *participants*, while *students* will be used to refer to pupils in schools.

2. 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 the ten-week period. The curriculum for this module 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 pupils/other learners and reflecting on teaching or learning episodes, as well as *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 with and 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 it in the classroom or another learning environment and evaluate its use with reference to teaching and learning of mathematics and connections with the literature. In each theme, at least one task will form the basis of an online group discussion. Contribution to online discussion forums include written observations on views and perspectives of fellow participants. The tutors also contribute to these discussions, with the aim of encouraging informed reflection and raising critical awareness of research literature.

2.2 Pedagogical underpinnings of our online course and guiding framework

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. A detailed description of the components of this frame could be found in Mishra & Koehler (2006). 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 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, we 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 through analysing and reflecting critically upon learning experiences with digital technologies, 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 own TPACK knowledge (as reported later in this paper in the case study), writing about such experiences (either as part of their online contributions to online forum discussion and as part of written assignments for this module) 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). We 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.

We 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 knowledge was needed in order to comprehend what the learning episode was about, the written format of these asynchronously shared experiences proved to be time consuming, hence the participants rarely reached as far as engaging themselves explicitly with the research and analyse ‘why that happened’, i.e. how theirs or their students’ mathematical work was affected by the use of the new technology.

As tutors, we came to realize that what was needed were opportunities for the participants to make their contributions grounded in *episodes* available to *share* by everybody on the course, which would allow participants to exchange views and share insights into learning of mathematics when technology is being used, as portrayed in those episodes.

For the new presentation of the course (starting in January 2016), our goal was thus to provide the participants with *shared episodes* of students’ doing mathematics with digital technology and support them in analysing and interpreting these episodes with a view of informing their future pedagogical decisions. Our hypotheses was that by developing the participants’ TPACK with a focus on students’ thinking about and learning of mathematics while using the digital technology, we will help the participants on our course develop skills of noticing and interpreting classroom events when teaching mathematics with the new technology, by linking the practice with the research knowledge base of the course, which in turn prepares them to make informed decisions about use of digital technology that will benefit their participants’ learning, hence contributing to the development of their TPACK.

Through this Masters level course, our 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 this pedagogical intervention, our intention was to support the participants make their conversations more grounded in actual events, more insightful, and more resistant to oversimplifications, thus scaffolding our participants towards more active engagement in undertaking enquiry themselves, which ultimately will benefit their students.

We 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 research knowledge base of the module (Figure 1). We refer to this frame as teachers' Research informed Technological Pedagogical Content Knowledge (RiTPACK – our own acronym for this frame).

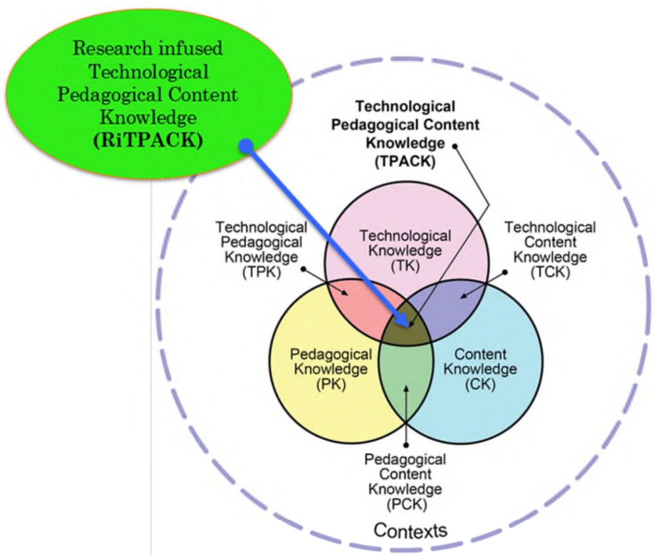

Figure 1: RiTPACK frame

3. THE INNOVATION: ONLINE VIDEO CASES

Guided by Van Es and Sherin's (2002) study, we 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 participants' 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.

However, 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 our participants' development of TPACK through reflecting on how the digital environment could support participants' mathematical work, we created and used online video cases in the new presentation of our module. The researcher (also a tutor on this course) 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), we 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 participants' learning benefitted (or not) from doing mathematics in a digital environment). Our 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. In our research study, the video cases produced are recordings of the work of a pair of student, 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 module 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 and student-teacher interactions while working through the mathematics activity.

3.1 Description of the video cases

The following four short videos were produced:

Video Case 01 (3min)	**Video Case 02** (8min)	**Video Case 03 Part A** (1min)	**Video Case 03 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 pupils' work while investigating the nature of the quadrilateral made by joining up the mid-points in a quadrilateral.	Recording of pupils' 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 questions 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.

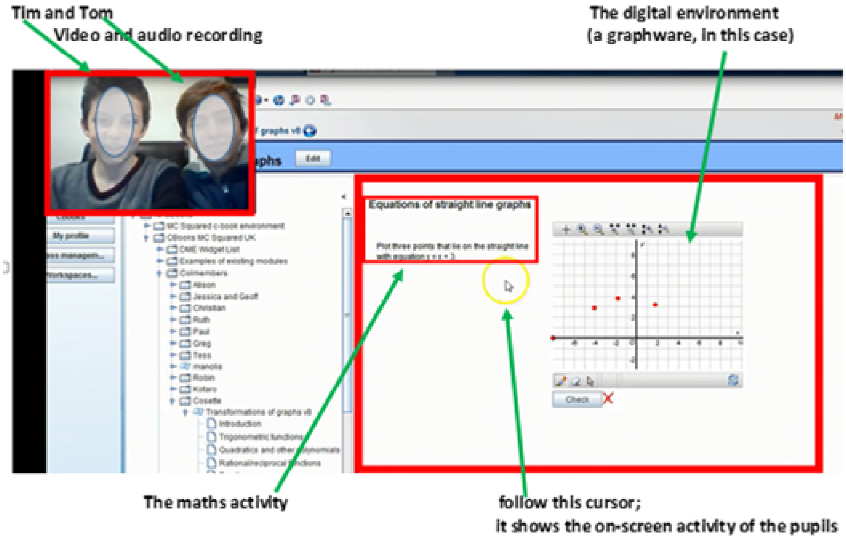

Figure 2: A screen shot from video case 01

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 participants and parents' consent, where the researcher's intention on how to use the video material and for what purposes was clearly explained.

During the second presentation of this online module in (Spring 2016), we 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 2 to 4 of the course, the course participants explored the value of access to multiple representations in terms of the potential to facilitate participants' 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).

4. METHODOLOGY: MODELLING RiTPACK

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, we were guided by the findings of Van Es & Sherin (2002), namely that video is as a tool that can help teachers develop their ability to 'notice' what is happening in a classrooms. Hence, for this task the participants were invited to strategically select particular sequences of the uploaded videos that were significant to them and write their reflections on how the students' learning has 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 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. Through the use of a selection of video cases, our intention was to support the participants make their conversations more grounded in actual events and more insightful.

The tutors on the course provided scaffolding for the participants by modelling engagement with research 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 moments and episodes in one of the video cases, how she annotated the video to focus on specific aspects of students' interactions with the digital tools 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.

In their analysis and interpretation of the learning episodes the participants were encouraged to be consistent in making connections between research & theory reviewed and their observations of the pupils' 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 pupils 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. van den Berg (2001) highlights 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 students to look more deeply than they might otherwise have done. Taking this suggestion into account, we too guided our 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?

5. PARTICIPANTS AND DATA SOURCES

The participants on our second presentation of the online course have all agreed for their written contributions to be used as data for our research study. Thus the data collected and analysed for the purpose of the study reported in this chapter consisted of the participants' online contributions to analysis and interpretation of the chosen episodes from the four video cases. We have also looked for further evidence of the participants' engagement with the research and theory in their final assignment for this module, which comprised of the design and evaluation of a sequence of mathematical activities that exploited the possibilities of digital technologies. This piece of work documented the participants‘ personal development of a mathematical idea or topic based on their exploration of digital technology and their reflection on their experiences of designing and trialling the teaching and learning of a mathematical idea or topic that exploits digital technology.

Data were analysed using the RiTPACK lens, which enabled us to identify in teachers' written comments (descriptions, analysis, interpretation of learning) explicit instances where their analysis and interpretation of the mathematical learning was research informed.

The evaluation of our pedagogical intervention consists in analysis of the developing quality of a variety of the written contributions of the participants throughout the delivery of this course. In this chapter, we will be reporting on one of the participants' (Mark - pseudonym) developing RiTPACK.

6. DATA ANALYSIS: 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. Mark, an experienced mathematics teacher, expressed his own views about the potential of ICT: *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.*

In week 1 of the online course, the participants were introduced to some key readings aimed at engaging them with the TPACK model. For this written task, 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 examples. Like most of the other participants on this course, Mark did not illustrate any of the claims about 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 practiced 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). Under his TPK, Mark envisages 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* (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* (TPK) (forum contribution, MarkTPACKstory, week 2).

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, inferred possibly from reading the literature, but with no specific reference to the actual mathematics investigation, 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: *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 performing the task.

While we wanted Mark and the other participants to continue to engage with research through using the ideas assimilated from the literature reviewed, we wanted to support them in making their writing grounded in actual events, either in their own learning or in their teaching or their students' learning, by focusing on 'what is actually happening and how and why' when doing mathematics in a digital technology environment.

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 received 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). We 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. 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). He go on to draw 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. 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).

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, 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 students reference to being able to "see" the Theorem seems to link closely with the research on visualisation for* *understanding* (End of course assignment). Early in his assignment, Mark explains how his review of the literature on visualization influenced his design of the student task: *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). 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).

7. CONCLUSIONS

The analysis of Mark's written contributions over the first four weeks of this course indicated that Mark's RiTPACK is developing. While there is evidence that Mark started developing his TPACK and engaged with research prior to and also 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 engagement with the video cases (our 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, our 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 module rather than just ingurgitating messages that 'experts' put forward/ proclaim about the potential of digital technology.

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