Using video cases to encourage participants' engagement with research and theory: Emergent pedagogies from an online course on digital technologies for mathematical learning

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In this paper we present the model behind our on-line master level module *Digital Technologies for Mathematical Learning*, which focuses on the teaching and learning supported by digital technologies. In our evaluation of the delivery of this module over two years, we reflect here on the emergence of two pedagogies: the online pedagogy of the tutors, ensuring that online teaching and learning is effective and the participants' developing RiTPACK (Research Informed Technological Pedagogical Content Knowledge - our own acronym for this concept) as they start experimenting with using the digital technology in their classroom practice and linking it with the research knowledge base of the module.

Keywords: digital technologies; RiTPACK; video cases; online pedagogy

Introduction

When we were first presented with the challenge of designing an online master's module for digital technologies for the learning of mathematics, our main aim was to support our students in learning about relevant literature on digital technologies, interacting with a variety of digital tools, but also helping them gain confidence in using them for educational purposes. Most of our students (whom we will refer to as participants throughout this paper) are full-time teachers or recent graduates of degrees involving mathematics or other mathematics related disciplines. The structure and the curriculum for this module was carefully designed to achieve the aims mentioned above, but also to improve the participants' academic skills through tasks involving carrying out small research studies, designing digital resources, trialing them with a group of learners and reflecting upon the outcomes by producing a written output. Through this process, our participants were encouraged to practise their academic writing and their 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.

We conducted an evaluation of this master's module after its first presentation and we report on the emerging pedagogies: 1. the online pedagogy of us, the tutors, ensuring that online teaching and learning is 'effective' and 2. that of the participants as they started experimenting with using the digital technology and critically reflecting on its potential and limitations for the learning and teaching of mathematics by linking the practice with the research knowledge base of the course.

In this paper, we plan to give a brief description of the structure of this online module, a brief account of the implications for the tutors and for the participants that resulted in the emergence of the tutors' online pedagogies and describe, through a case study, how the use of online video cases supported the development of the participants' RiTPACK.

The structure of the module

The module is delivered in 10 weeks and each week the tutors upload on the UCL Moodle platform, (1) the Learning Objectives and a description of that week's content, (2) an essential reading and an indicative one and (3) the weekly tasks, which are tightly structured towards the course aims and learning objectives. The participants are required to carry out the weekly tasks, to go online and post their reflections, but also respond to their peers' posts. Since this is an online course and in an effort to promote online discussions and collaborations, we inform the participants that online presence is taken to indicate attendance. Instead of direct teaching, learning is designed to take place as the result of doing short, manageable tasks, which as mentioned above are posted on a weekly basis. There are offline tasks, which include (1) familiarising with a piece of software and going through scaffolded activities using specific software, (2) designing and trialling maths activities involving the specific software that bridge learners' interactions with digital media and the mathematical concepts and (3) reflecting on teaching or learning episodes trialled. The online tasks, on the other hand, include: (1) engaging with the ideas in the key readings, for example, by reading one of the essential reading articles and writing a response about the points they agreed or disagreed with or by contributing to online discussion forums with written observations on views and perspectives of fellow students; (2) reflecting on the application of the ideas encountered in the key readings in specific learning contexts.

The design of this course has been influenced by the Technological Pedagogical Content Knowledge (TPACK) framework (Mishra & Koehler, 2006). 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. The participants on our course, either practising 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 TPACK.

The online pedagogy of the tutors

Designing and delivering an online master's module was a new experience for us, certainly challenging but at the same time rewarding especially when we realized how some of our decisions promoted better learning outcomes for our participants. This process also resulted in us developing a different type of pedagogy, which we like to refer to as online pedagogy.

We realised that our role shifted from that of a subject matter expert, a course developer and a lecturer to also include that of (a) a technology trainee as we had to ensure that we were familiar with a variety of digital tools that we were using in this module, (b) a trainer, as we had to support our participants with any issues regarding these tools and finally (c) a facilitator or moderator, as we had to manage their online contributions and encourage their online 'presence' through the online forum

discussions and submissions of tasks and peer feedback. The latter role proved a challenging one mainly due to the online nature of the course and the participants' experience and familiarity with mainly face-to-face sessions for masters' modules. Our actions, which proved effective in the consecutive years of delivering this module, were to include (a) tasks that formed the basis of an online group discussion, (b) collaborative tasks for tutor-allocated groups and (c) pick-a-paper tasks, i.e. "choose one paper and its commentary from a participant in your group and post your comparative remarks and reflections". One of the participants' comments in their end-of-module evaluation was "I wonder if it might help in the student discussions if the tutors prompted us for input or directed us to particular aspects of the readings". So, we also contributed to these discussions, with the aim of encouraging informed reflection and raising critical awareness of the relevant research literature. In our efforts to give constructive feedback on participants' work, we shared with all participants' general comments on all weekly tasks, raising common issues and drawing their attention to crucial pedagogical aspects when using digital technologies and providing them with personalized feedback on their tasks at the end of each of the three themes.

Reflecting on the outcomes of this module's first presentation, we recognised the need to keep the online course 'alive' by (a) ensuring our weekly presence by encouraging and prompting discussions and (b) encouraging collaboration between participants through carefully designed tasks.

The participants' RiTPACK pedagogy

While the participating teachers reported development of their own TPACK knowledge, sharing such experiences (both 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 teachers (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. For instance, during the weekly online discussions the participants provided narratives of their own learning or classroom based experiences with the new technology, but these narratives were mainly about 'what happened' with little attention to how students' mathematical work was affected by the use of the new technology.

The innovation: Online video cases

For the next presentations of the course, our goal was thus to provide the participants with *shared learning episodes* and support them in analysing and interpreting them with a view of informing their pedagogical decisions. Our hypotheses was that by developing the participants' PACK with a focus on students' learning of mathematics while using the digital technology, we would help the participants 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. We refer to this pedagogy as teachers' RiTPACK.

Guided by Van Es and Sherin's (2002) study, we considered the use of online video cases in order to support our participants' development of TPACK through

reflecting on how the digital environment supports students' mathematical work. The researcher (also a tutor on this course) planned for and recorded a number of videos of two Year 8 students, Tim and Tom (pseudonyms), both age 12, attending two different secondary schools in a large city in the UK. The videos show the boys talk through the activities 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. A description of the design and content of these videos is provided in Crisan (2016).

For the end of theme tasks, the participants were invited to strategically select particular sequences of the uploaded videos that were significant to them and write their reflections on students' learning and doing of 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 students' learning as portrayed by the video cases.

Researchers (e.g., Van Es & Sherin, 2002) have written about the benefits of using videos in teacher education programs. It has been reported that students 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. *Our intention was to address* Leat, Lofthouse and Reid's (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.

Evaluation of the pedagogical intervention

The following is a report of one of the participants' (Mark - pseudonym) developing RiTPACK, as evidenced in his written contributions (online or otherwise).

Prior to the start of the course, all the participants on this course were asked to submit a short piece of writing about the use of digital technologies in their own learning and teaching of mathematics. Mark, an experienced mathematics teacher, expressed his own views about the potential of digital technologies: "Much technology used inappropriately simply does the same thing as non-technology, but used well [it] has the ability to add significant value." He has invested into developing his TK: "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, and so he now hopes that I am getting to the point of pay off."

In the first week of this course, the participants were introduced to some key readings aimed at engaging them with the TPACK model. Like most of the other participants on this course, Mark failed to illustrate any of the components of the

TPACK framework with specific examples from his own experience with digital technology or from his own classroom practice. Instead, his writing consisted of assertions about the potential of using digital technology in doing mathematics, without being clear if they were inferred from his practice or if they were just personal opinions without any empirical evidence. For example, Mark remarks that "Computer system is engaging. It allows students to experience a variable by dynamically changing it and seeing the results "what is the same, what is different". Under his TPK, he 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."

For the following two weeks of this course, the participants explored the value of access to multiple representations in terms of the potential to facilitate students' understanding of various areas of mathematics. When reporting on his own investigation on how the parameters in the general form of a quadratic equation were related to the graphical representation of the equation, 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 students on the connections between them." This again is a claim about the potential of using digital technology, with no evidence of whether or not Mark inferred it from reading the literature or as a result of reflecting on 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 engages 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 students minds since they will see multiple images of the same problem. This can only enhance students understanding and engagement (from Laborde, 2005)", but he fails to link the research knowledge base of the course with his own experience when performing the task.

For the end of theme task, Mark selected an episode from a video showing Tim and Tom which 'started' 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 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." 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. He draws 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."

The analysis of Mark's written contributions over the first four weeks of this course provides convincing evidence that the video cases supported him 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).

Conclusions

When designing and delivering this module, our goals included the promotion of the use of digital technologies for mathematical learning. Throughout the delivery of the module the participants were supported in becoming more actively engaged with the research and knowledge base of the module. The use of online video cases was a pedagogical intervention which raised participants' awareness of 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. We provided evidence which supports our finding that such intervention contributed to the development of the participants' RiTPACK. Together with the use of carefully designed activities, we also supported the links between interactions with digital resources and the mathematical concepts, empowering our participants to make informed decisions about the use of digital technology that will benefit their students' learning.

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