

Scaffolding With and Through Videos: An Example of ICT-TPACK

[Kathrin Otrel-Cass](#)
Aalborg University

[Elaine Khoo](#) and [Bronwen Cowie](#)
The University of Waikato

Abstract

In New Zealand and internationally claims are being made about the potential for information and communication technologies (ICTs) to transform teaching and learning. However, the theoretical underpinnings explaining the complex interplay between the content, pedagogy and technology a teacher needs to consider must be expanded. This article explicates theoretical and practical ideas related to teachers' application of their ICT technology, pedagogy, and content knowledge (TPACK) in science. The article unpacks the social and technological dimensions of teachers' use of TPACK when they use digital videos to scaffold learning. It showcases the intricate interplay between teachers' knowledge about content, digital video technology, and students' learning needs based on a qualitative study of two science teachers and their students in a New Zealand primary school.

Research evidence on information and communication technology (ICT) use over the past two decades shows a growth in the availability of ICT in schools. It also highlights, amongst other things, that ICTs can facilitate a move toward a learner-centered approach to teaching (Means & Olsen, 1994). However, especially if teachers simply use ICTs to replace more traditional teaching tools or merely add them into existing practices in a superficial manner, a learner-centered approach is not easy to achieve (Oliver & Herrington, 2000).

When teachers inform their pedagogical practices with their knowledge about the affordances of technological resources, they draw on what has been described as technological pedagogical content knowledge, also known as technology, pedagogy, and content knowledge (TPACK; Koehler & Mishra, 2008; Mishra & Koehler, 2006; Schmidt et al., 2009). TPACK describes the social and technological dimensions of pedagogy when teachers use technology to support their teaching, but teachers need to learn how to plan their teaching with supporting technology in mind.

Current research on the pedagogy of teacher education recognizes the need to make tacit concerns, such as teacher' beliefs regarding ICTs and their suitability and appropriate application into teachers' practice, more explicit (Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, & Sendurur, 2012; Loughran, 2006).

Studies by Niess (2005) and Forbes (2011), for example, illustrated that focusing preservice teachers on the integration of different technologies helped them consider how this integration supported a particular curriculum focus. They also pointed out a lack of research that could help increase teachers' understanding of the potential for specific ICTs to support teaching and learning. This lack is a significant consideration in terms of the subject-specific needs science teachers face in eliciting and shifting students from everyday to scientific understandings of the how the world works.

In this paper, we adopt Selwyn's (2004) description of ICT as "an umbrella-term for a range of technological applications such as computer hardware and software, digital broadcast technologies, telecommunications technologies such as mobile phones, as well as electronic information resources, such as the World Wide Web and CD Roms" (pp. 346-347). For science teachers, ICTs may encompass an even greater variety of tools, including specific educational digital technologies such as digital microscopes and data loggers, and digital videos of experiments that are too dangerous or difficult to conduct in a school setting.

Research into ICTs has been plentiful in recent years, with a focus on the value of specifically designed software (Libarkin & Brick, 2002; Linn & Hsi, 2000; Papastergiou, 2009; Zibidis, Chionidou-Moskofoglou & Doukakis, 2011) and on ICT as a homogeneous concept for driving educational change (Ottestad 2010; Selwyn & Facer, 2007). Yet, there is still a need to extend the scope of analysis from a focus on the affordances of ICTs to an examination of how teachers take up these affordances and integrate them meaningfully in the curriculum (Fjuk & Ludvigsen, 2001).

Trautmann and MaKinster (2010) pointed out that, although developing the skills to use specific ICT is important for teachers, they also need to develop a vision of how and when they can best use these technologies in their teaching. Not surprisingly, teachers from different curriculum areas conceptualize and use ICTs in different ways (Hennessy, Ruthven & Brindley, 2005), and science teachers are often amongst those who are the most enthusiastic users (Cowie et al, 2008). In this article, the nature of teacher science-specific TPACK (or ICT-TPACK) is of interest in relation to teacher use of digital videos to scaffold primary student science learning. Digital video use in science classrooms provides a fresh context for studying the dimensions of science-specific TPACK.

Teacher Use of Digital Videos in Scaffolding Science Learning

Video use to support teaching and learning in science is not novel. Videos have been used in science classrooms since the 1950s as a form of representational and communicative resource (Kress, Charalampos, Jewitt & Ogborn, 2006). However traditionally teachers

and students have had only limited control over content of videos. Videos were often used as a reward, as a largely passive activity for students (Kearney & Treagust, 2001). Interaction was only possible if and when the teacher turned the video off to pose a question or raise a point for discussion; however, earlier technologies made this difficult (Zollman & Fuller, 1994).

Kearney and Treagust (2001) used the term *interactive video* for digital video technology because it is easily accessed through computers from the Internet or from CD Roms. Digital video offers teachers more control over what is shown. The videos are easy to stop if a teacher wants to respond to questions of interest or confusion, and particular sequences can be selectively reviewed as a way of providing feedback. Recent research on digital video use has focused on higher education (Mitra, Lewin-Jones, Barrett, & Williamson, 2010; Sherer & Shea, 2011), as well as the social sciences (Florez-Morris & Tafur, 2010), but few studies have focused on the use of digital video in primary science teaching. This lack is a concern, particularly since access to digital technology has increased in schools dramatically in recent years (Mardis, 2009).

In light of the ubiquitous teacher and student access to the Internet and World Wide Web that facilitates spontaneous and instant use of video resources such as YouTube and user-friendly video production facilities on mobile phones (Buckingham & Willet, 2009), it seems appropriate and important to examine how digital video can impact classroom practices. Classroom video use can include the viewing of professionally produced videos as well as the production and viewing of student- and teacher-produced videos (Osborne & Hennessy, 2003). That is, students and teachers can be producers as well as viewers or consumers of videos. Videos provide unique opportunities to capture, process, research and present information and can even promote critical teacher-student reflection of their classroom experiences (Rosaen, Lundeberg, Cooper, Fritzen, & Terpstra, 2008).

Producing a video can help 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). Student-produced videos have the added benefit of not being cleaned of everyday ideas or language, thus offering the potential to document children’s and young people’s developing ideas (Hennessy et al., 1995). In this sense, digital videos can be a means for students to be creative while providing an authentic and multimodal record of their ideas and how they were developed (Williamson, 2006). Moreover, gains in technology now allow users to share and collaborate on materials they have produced themselves. The ease of sharing their work with each other and the rest of the world can be a powerful incentive for students.

The identification of the audience directs the tone and voice of what is being said. Although videos can capture everything, the camera can, in fact, record only what is within the frame of the lens as it is positioned by the user. Student-produced videos allow the audience to become involved with the students’ world while allowing the audience members to use their own senses to experience and emphasize what has been captured (Pink, 2007). Videos produced by young people also foreground the symbols, expressions, and cultural tools they deem to be relevant to the story they want to tell (Niesyto, 2000), allowing the students’ voices to come through. Student video recordings can provide an opportunity for them to recall ideas and to practice a specific language while they are supported through the power of visualization (Hung, 2009).

In the science classroom, videos can be used to illustrate potentially dangerous, costly, or hard-to-access phenomena. They can bring relevant real-life examples into the classroom and connect school science with the world outside (Kearney & Treagust, 2001). Additionally, demonstrations that cannot be conducted in school or can be conducted

only once can be shown repeatedly. However, such use requires careful planning to ensure the video makes a timely and productive contribution to student learning. The careful orchestration of digital video in support of meaningful pedagogical practice is the focus of the next section where we illustrate what is meant by teachers' TPACK and more specifically ICT-TPACK.

TPACK to Support Classroom Transformations

TPACK for the use of specific ICT has been an area of focus for research and development in teacher use of ICTs for some time (Loveless & Ellis, 2001; Mishra & Koehler, 2006).

TPCK [technological pedagogical content knowledge] is what makes a teacher competent to design technology-enhanced learning and can be described as the ways knowledge about tools and their affordances, pedagogy, content, learners, and context are synthesized into an understanding of how particular topics that are difficult to be understood by learners or difficult to be presented by teachers can be transformed and taught more effectively with technology in ways that signify the added value of technology. (Angeli & Valanides, 2008, p. 25)

TPACK revolves around the use of technology as a subset of pedagogical content knowledge (PCK; Shulman, 1987). PCK involves the synthesis of a teacher's pedagogical knowledge with content knowledge to contribute to a better understanding of how aspects of a subject can be best organized, adapted, and represented for teaching-learning purposes. TPACK involves the integration of teacher knowledge about the properties of and opportunities that technology has to offer, that is, its *affordances* (Norman, 1988; Pea, 2004) that might make it the optimal choice to support teaching *this* content to *these* students. The complex interactions between teacher content knowledge, pedagogy, and technology are thus the foci on TPACK. Extending teachers' understanding of TPACK requires systematic development on how to plan for and implement technology to suit and support learning outcomes that are subject specific (Angeli & Valanides, 2008).

Drawing on the work of prior authors, TPACK is described as the intersectional relationship of six components (see Table 1; Koehler & Mishra, 2008; Mishra & Koehler, 2006; Schmidt et al., 2009).

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 refers, then, to the combination of these components to describe the knowledge a teacher draws on when technology is used in support of content-specific teaching

approaches. The value of TPACK lies in the unpacking of the components and the considerations of what the combination of these components afford. Such understanding is specific to the content involved, which means that science teachers' TPACK is different from that of other subject teachers. The technologies accessed and used in science classrooms can be quite diverse. Information and communications technologies are a subset of these technologies that allow students to communicate and share information with others. The following section explores why ICT-TPACK needs to be considered as a specific form of TPACK.

ICT-TPACK as a Specific Analytical Frame

In this article, we describe what it means for science teachers to apply their knowledge of a specific ICT and how it can be made relevant to pedagogy, content, and students. We adopted Angeli and Valanides' (2009) distinction between TPACK and ICT-TPACK. These authors define ICT-TPACK as knowing how

tools and their pedagogical affordances, pedagogy, content, learners, and context are synthesized into an understanding of how particular topics that are difficult to be understood by learners...can be transformed and taught more effectively with ICT, in ways that signify an added value of technology. (p. 159)

They argue for greater consideration of what it means to use ICTs to support teaching and learning in terms of facilitating greater student communication, connection, and collaboration in contrast to the affordances of technologies that cannot communicate through digital means, for example, a standard microscope or dissection kit.

Graham (2011) supported the refinement of TPACK. He noted that Koehler and Mishra did not distinguish between the types of technology available to teachers when they first described TPACK. Angeli and Valanides (2009) used the same six components as Mishra and Koehler (2006) but extended them with descriptions specific to ICT. Table 2 highlights (in italics) the specific additions made by Angeli and Valanides. The descriptions of CK, PK, and PCK, align with Mishra and Koehler's earlier description.

ICT-TPACK requires teachers to be forward looking to consider how students might perceive and make use of the affordances of an ICT tool in science to collect, represent, and communicate their ideas to others. In order to illustrate the enactment of ICT-TPACK we examine scaffolding in the next section as a specific pedagogical strategy and our second theoretical construct.

Examining ICT-TPCK Through the Practices of Scaffolding

Scaffolding is an instructional process that enables novices to carry out a task that they would otherwise not be able to achieve (Wood, Bruner & Ross, 1976). The term *scaffolding* refers to the interactional operations between teachers and students and encompasses both structures and processes (Pea, 2004). Referring to the works of Vygotsky (1978), as well as Rogoff and Wertsch (1984), Pea explained that the term scaffolding may encompass structures such as software programs, but also curriculum structures or conversational features such as questioning, as well as physical structures that promote classroom learning.

Table 2
ICT-TPACK Components Expanded

ICT-TPACK Components	Component Descriptors
ICT-TK or ICT technological knowledge	<i>Knowledge of ICT software and hardware, including how to access, install, remove, create and/or archive digital material</i>
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 matter or content
ICT-TCK or ICT technological content knowledge	<i>The knowledge of how specific ICT may be used to support, amplify or assist to compound subject content, for example, how digital video technology affords new ways of representing and documenting science observations.</i>
ICT-TPK or ICT technological pedagogical knowledge	<i>The knowledge of the existence of specific ICTs, including the knowledge of how to use particular ICTs to enrich communication, enhance connection and collaboration between people and how teaching may change as a result of using ICT.</i>

Pea elaborated that scaffolding is guided by a teacher's assessment of "a child's capabilities and needs" while identifying which aspects of activities require particular scaffolds to achieve envisaged outcomes" (p. 425). Through the careful selection of teaching materials and artifacts they provide students with the tools to accomplishing learning tasks that can be achieved through scaffolding.

Puntambekar and Kolodner's (2005) description of *distributed scaffolding* indicated that teachers can draw on a variety of materials and social supports to help their students develop the skills and knowledge needed to work independently. Tabak (2004) unpacked this notion further to argue that the term distributed scaffolding draws "attention to marshalling and orchestrating multiple resources to support learners and to understand how these interact" (p. 307). She explained that distributed scaffolding can be differentiated, redundant, or synergistic. These three forms of scaffolding are used in this paper.

Differentiated scaffolds provide support for the multiple but disconnected tasks that students engage in when they are involved in complex activities. Differentiated scaffolds respond to individual needs so that all students are enabled to refine and enhance their understanding and skills about the world.

Redundant scaffolds refer to different scaffolds that address the same need based on the understanding that not every student will benefit from the same scaffold. If students miss out because a particular scaffold was too complex or offered before they were ready, redundant scaffolds provide further supported opportunities for students to accomplish the same task.

Synergistic scaffolding refers to scaffolds that support and augment each other to help students accomplish an activity. Some skills and understandings require a sophisticated blending of “knowledge, skills and values” (Tabak, 2004, p. 318). With synergistic scaffolding this complexity can be supported through the intertwined use of multiple scaffolds. Through the flexible uses of synergistic scaffolds, the likelihood of students using tools and ideas independently and for more advanced investigations is increased.

Where such scaffolding interventions involve digital technology, teachers need to make use of their ICT-TPACK to understand and explore the depths of content and context-related challenges and opportunities (Angeli & Valanides, 2009). However, ICT-TPACK is necessarily contextualized by the knowledge and skill demands in teaching and learning a particular subject area.

As Mishra and Koehler’s (2006) explained, “Developing theory for educational technology is difficult because it requires a detailed understanding of complex relationships that are contextually bound” (p. 1018). In what follows we show how teacher digital video specific ICT-TPACK shapes the way two teachers evaluated and used digital video technology to support student learning of three science topics, as well as how they responded to pedagogy-, content-, and technology-related challenges.

Research Context, Method, and Analysis

Context

This article draws on work that was done as part of the SCIANtICT (Science Classroom Investigations of the Affordances in Teaching with ICT) project, funded through the New Zealand Teaching and Learning Research Initiative. It involved a team of three university-based researchers and two primary school teachers, Tina and Cindy (pseudonyms are used in this study), and their two Year 7-8 classrooms (students aged 11 and 12 years). The study was conducted over a period of 2 years (2009-2010) with an overall aim to explore the potential of ICTs for teaching and learning science with diverse groups of students (Otrrel-Cass, Cowie, & Khoo, 2011).

The SCIANtICT project aimed to determine and theorize about how teachers might use ICTs to support student science learning. The project was organized into three phases: identifying existing practices, redefining practices, and enhancing practices. This article reports on data generated during the first phase, where emphasis was on discovering how the teachers understood and employed ICTs to support student collaboration, communication, and access to and the production of multimodal representations of content. The teachers were already making use of digital videos. The ways they were doing this and the implications of this use for their students’ science learning became a research focus.

Methods

Qualitative data, including video and audio recordings of lessons, field notes, teacher and student interviews about classroom work, and teacher and researcher collaborative planning and analysis meeting discussion, were collected. This article presents findings from two classrooms and the 60 Year 7-8 students we had been working with. While the school did not stream students, one of the two classes was described by the teacher Tina as a lower band class. Cindy’s class was described as a higher ability class. The teachers in both classes shared the same intention for their students to learn how scientists collect, work with, and use evidence.

Both teachers shared the same teaching plan, an investigative unit on changes of state. This unit was taught in both classrooms over a period of 10 weeks. During this selected period we recorded 14 hours of classroom practices in each class. Researchers attended the lessons in teams and were present for at least one 60-minute lesson per week. Teachers and the researchers jointly selected the lessons that researchers attended during the planning stages of the units, but there was an emphasis on capturing more lessons at the beginning and the conclusion, with some recording of the middle portions of the unit.

Analysis

The SCIANTICT study used a collaborative approach to data analysis (Armstrong et al., 2005), based on Lesh and Lehrer's (2000) model of iterative video analysis. A sociocultural viewpoint underpinned the investigation of the teaching and learning and the analysis of data. This approach directed our attention to the ways actions and interactions with ICTs in the science classrooms are shaped by the participating individuals and their social practices (as in Cole & Engström, 1993; Wertsch, 1998).

Iterative cycles of collaborative analysis involved teachers and researchers in independent viewing of selected video-recorded episodes of classroom activities followed by group viewing and discussion of these instances to reach a shared interpretation. After several iterative analysis cycles of discussion between teachers and researchers, we identified several themes regarding video use in the classroom to extend our thinking about what a digital video specific pedagogy could look like.

We used the six components of ICT-TPACK (see Table 2) in our analysis to zoom in and identify aspects of the teachers' science-centered practices. The teachers' pedagogical approach (PK) was conceptualized as one of scaffolding. This choice was made because the idea resonated with our teachers as a means of encompassing the complexity and their developmental use of digital videos. The findings that follow elaborate on the nature of ICT technological pedagogical knowledge, recognizing that the whole is more than the sum of the parts. That is, ICT-TPACK derives its value through the integration of the different components.

Overall, triangulation of different types of data sets and data collection methods (Lincoln & Guba, 1985) occurred to strengthen the reliability of our study. This included member checking amongst the researchers and also teachers to ensure that the interpretations of the findings were robust (Stake, 1995).

Findings

Four episodes are presented to illustrate teacher ICT-TPACK, where the two teachers used distributed scaffolding to facilitate students' science learning. The examples show the teachers' scaffolding actions and how they used digital video technology to highlight the interplay between content, pedagogy, and technology. The selected episodes represent contexts of teachers' use of digital video when they were teaching science to exemplify their knowledge construct of ICT-TPACK. The examples include video use to support teacher planning and assessment, video use to scaffold students' science ideas and vocabulary, and finally, video use to link prior understanding and activities in preparation for a practical science investigation.

Videos to Scaffold Planning and Assessment

In the first two episodes, both teachers used student-produced video clips in support of their teaching. The two teachers had a number of flip video cameras available at their school, which were simple to operate, with a built-in USB port that allows quick and easy downloading. The flip video camera also permits instant reviewing and the possibility to rerecord if deemed necessary. Both teachers explained that they had used the flip video cameras before with their students, so they knew that the students were familiar with the hardware and software setup specific to the type of video camera.

Tina's Class. The first episode is from Tina's class. According to our field notes, Tina planned to ask students (working in pairs) to video record each other talking about how scientists collect evidence. She planned this activity as part of her formative assessment strategy. The students interviewed each other at the beginning of the unit and uploaded short video clips into individual student blogs. The individual blogs were only accessible by the teacher and the individual students. Tina's use of videos to access her students' existing ideas allowed her to take into consideration incomplete or false beliefs and critical misconceptions (Driver, Asoko, Leach, Scott, & Mortimer, 1994). After viewing the videos, Tina reflected in an interview,

I used this peer-share strategy as a way of reducing the risk for students to share their ideas in front of the whole class....It was also a way for me to listen into students' conversations to see what they were or were not saying...I could instantly see students who still had nothing to say and knew that I would have to sit with them later more casually and try and find out what they were thinking. For those students who were discussing the questions I had given them, I could see where their thinking was at. I could build a clear picture of what individuals understood, could recall, or any misconceptions they held. This also helped me figure out where to go next for the class.

The following transcript is from one of the student-produced videos where students interviewed each other at the beginning of the unit:

Bryan: Hi, my name is Bryan.
Isaac: I'm going to be asking you some questions about science.
How does a scientist get evidence?
Bryan: I don't know [Shrugs his shoulders]
Isaac: How does a scientist work with evidence?
Bryan: [Seems unsure, shrugs his shoulders but remains silent]
Isaac: Don't know?
Bryan: Yeah.
Isaac: How does a scientist use evidence?
Bryan: [Silence. Bryan frowns and shrugs his shoulders]

Tina commented after watching her students' video clips that she had been disappointed at the lack of connection with science that some of her students evidenced. She made developing this connection a priority for the unit:

When I watched this set of videos...I felt so sad that some students were so disengaged with science that they didn't realize how connected they really are or can be with science. So from here on in I really wanted to make sure they understood that anyone can be a scientist, or work/think like a scientist.

Tina used this approach of student-produced video interviews again at the end of the unit to compare before and after views as part of assessing if and how students' understandings had shifted. Tina asked the students to use the same questions in the video interview they initially asked. It became apparent that Bryan's understanding of the sources of evidence and ways scientists use evidence had been expanded, as illustrated in this excerpt transcript from his video.

- Isaac: How does a scientist get evidence?
Bryan: By going into computers, laptops, reading books or they use the glass thing [Listens carefully, answers quite confidently].
Isaac: How does a scientist work with evidence?
Bryan: [He thinks first before answering the question]. They use equipment. They plan it. They use their method.
Isaac: How does a scientist use evidence?
Bryan: [Thinks first and then answers]. By experimenting, microscopes and examining and doing it carefully.

This second student-produced video was part of an assessment strategy that gave Bryan and all other students an opportunity to share what they had learned without having to write. They reported on their learning to the teacher via a video of an interview with a peer. The video recording process formed part of Tina's differentiated scaffolding (Tabak, 2004) because it added a different mode of sharing knowledge. Furthermore it added a level of manageability of information for Tina, a point she reflected on later in an interview:

Using the digital videos was a way of tracking thinking, it was useful for me as a teacher as I could send them all away to do their video responses to set questions, which they uploaded, etc. I could then sit and watch 15 minutes of continuous video, which gave me insight into their thinking and uncovered many misconceptions or preconceptions, which needed challenging.

Using student-produced videos allowed each student to share their knowledge with Tina, something that would not be possible over the course of a regular lesson. In each case the videos provided Tina with information about student learning and how comfortable they felt about what they knew. Tina was able to assess their learning in an authentic and innovative way.

Cindy's Class. In the second episode, Cindy asked her students, to video each other talking about their ideas about how scientists work. In her class, however, she assigned one student to roam around the classroom as a reporter and record other students' ideas on video. After that the whole class watched the recording.

The class was watching the roaming reporter video together. This provided Cindy with a powerful forum to talk about what had been learned up to this point and what aspects of learning may need to be readdressed. This strategy allowed the students also to listen to each other on the video and hear how they talk science. (Field notes)

Used this way, the video provided evidence of students' science talk as a valued social practice. When reflecting on the use of student produced video and her pedagogical thinking, Cindy remarked, "I use different methods to build on students' confidence to

contribute to discussions....It [video] can be a very powerful tool for reinforcing ideas, promoting discussion or building on current knowledge.”

The idea that interviews could be videoed did not require any specific explanations, because students often watched these on television. However, each teacher drew on this information in a different way. Tina’s class had lower band students and her awareness and insights into what her students would feel comfortable with suggested to her it would be best not to share student reflections in public. In contrast, Cindy’s top band class was accustomed to the practice of talking about their ideas in front of each other. These contrasting examples show how the teachers’ applied their knowledge about their students to optimize the affordance of the videos to capture student talk about their prior knowledge and what they had learned.

Videos to Scaffold the Introduction of Science Ideas

Science talk as a meaningful practice in classrooms frequently involves pedagogical approaches such as teacher questioning or discussion that draws in student science knowledge (Yore, Bisanz, & Hand, 2003). However, in order to talk science, students need to be introduced to and make sense of science vocabulary and ideas.

In this third episode, Tina investigated with her students the changes of states of water, which meant students had to learn about the water cycle.

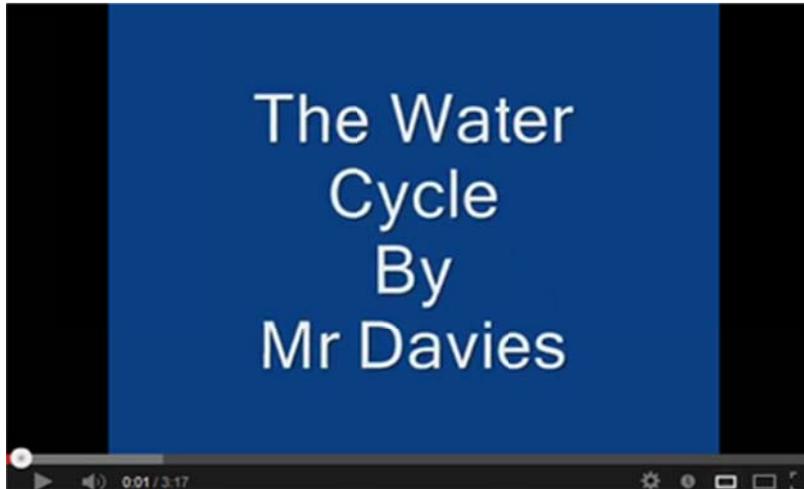
Today Tina used a video (YouTube clip) that was engaging and included clear and accurate information and definitions about the water cycle. It featured a catchy song with repeated use of science vocabulary (sung in the song and as printed words in the video). The video also included illustrations, the water cycle diagram and images of actual clouds, lakes and so on. (Field notes)

The multiplicity of scaffolds offered through the water cycle video clip (Movie 1) provided what Tabak (2004) described as redundant scaffolding, different scaffolds that supported the same need. Tina also uploaded the water cycle video clip onto the class website so students could access it during the unit if they needed or wanted to. Tina played the video to the whole class on a number of occasions, and both teacher and researchers observed that the students also watched it during individual work times over the course of the unit.

During our observations, we noticed students often hummed the song as they worked. We talked to the students about this in an interview:

Interviewer: Tell me what you remember about the video?
Cathrine: It talks about the clouds and the rain and evaporation
John: Transpiration. [He starts humming].
Interviewer: Anything else that you remember?
Cathrine: I remember about the storm and ‘Uncle’ whatever his name is who hid in the rubbish bin to get out of the storm.
Interviewer: What did you think about that video?
Cathrine: Funny at the end.
Interviewer: What’s funny?
Cathrine: It was actually quite educational.
Interviewer: What do you mean?
John: It tells you about precipitation and stuff.

- Cathrine: It tells you about the water cycle, runoff, precipitation and evaporation.
John: We used to watch it quite a lot.



Movie 1. *Water Cycle* from YouTube
(<http://www.youtube.com/watch?v=YswL4dIDQuk>)

From our conversation with the students, it appeared that the water cycle video reinforced science ideas and associated vocabulary through the use of symbols, images, diagrams, and printed and sung words. After viewing a recorded sequence from the classroom observation Tina wrote in her reflections:

The song and the video were a little gimmicky but it certainly had them engaged and the students were having fun in science, which was important to me to change some of their preconceptions they held about science. It was not unusual for students to sing along with the song, which in some way was unusual with Year 7/8 students, and I do think it helped a few students recall some basic ideas within the water cycle. When I am planning what images to use, moving and still, I always consider which ones might help the most, thinking about learning styles and preferences to help engage and convey ideas to the students.

In this example, the teacher's selection of the video to introduce science ideas was based on her knowledge of scientific models and her recognition that scientific discourse is at times multimodal and involves the use of semiotic knowledge represented in diagrams, symbols, or images (Lemke, 1998). The teacher was also aware that her lower band students are drawn to the audiovisual information presentation. It was unclear whether students' unprompted uses of the video were a function of its multimodal nature or whether the students were seeking out particular facts about the water cycle. Either way, the students used it as a valued cultural tool as part of the ongoing scaffolding that accompanied their learning journey.

Videos to Link Earlier Learning in Preparation for Practical Science Investigations

In both classes, the teachers showed their students videos to prompt them to think about upcoming science investigations. In this fourth episode, Cindy showed her students a video that was professionally produced and available through the website of a national television station. The video was part of a television program that investigates issues faced by consumers and advises on various household products to inform their purchasing decisions.

In the video, the presenters tested various brands of soap. The video highlighted critical aspects in the testing process to compare several brands of soap according to the length of time each one could last, the effectiveness of each in removing dirt, and consumer preference of a soap's fragrance and so forth. Results from the tests were tabulated, illustrating how each soap performed according to the specified criteria and their price to indicate their value for money. Well-known television presenters who, although they were not scientists, were able to communicate key aspects of the scientific fair testing process in an interesting, authentic, and meaningful manner fronted the video.

At one point the TV presenter called out, "It's science time!" drawing attention to particular ways of conducting experiments and seeking information. Cindy's students had spent the prior weeks learning content-specific information about changes of state, how scientists work and collect their evidence, and how to prepare for and conduct their own experiment. They were thus familiar with many of the ideas the presenters introduced. The video contextualized these ideas in an engaging and informal context.

Cindy applied her ICT-TPACK by showing the students this video to reinforce key points and prepare students for their own independent investigations, in particular, how they needed to think about collecting different kinds of data if they were to conduct a trustworthy scientific investigation. The video served as a scaffold to summarize, draw together, and reinforce what had been learned from a series of earlier classroom activities. Cindy's use of synergistic scaffolding involved intertwining earlier learning experiences with the video scaffold. During an interview Cindy reflected,

This particular Target program related to what I had been teaching, including fair testing, measuring, variables, testing, and collecting data in a variety of ways. The processes that were demonstrated were shown clearly and it was easy for the students to pick up on the science content of the video....I was able to stop the video and make reference to particular areas to reinforce certain points about carrying out an investigation. In this way the video was a catalyst for recording ideas about how scientists work.

We asked students in a group interview to reflect on the use of this video and its impact on their science learning:

- Karen: The different types, ways you can experiment, you can measure how long it lasts, how durable it is and its popularity.
- Michael: How you can test different things...
- Barbara: How cheap and how much it costs as well, better deal kind of.
- Ryan: About fair testing, making sure you keep everything equally. So that you know the test results are accurate. So they have correct results.

The students made links between the video and what they had learned earlier on how to work like a scientist. For example, “They tested it a few times in a different ways and that’s usually what scientists do. They tested them more than once” (Karen).

The video provided an effective link between the ideas students had learned about collecting evidence and their plans for doing their own investigation. Their reasons for liking the use of videos in their science learning included the following:

“It’s a lot more interesting. It makes you want to learn a lot more.” (Ruth)

“It’s visual and you can actually learn from actually seeing it, not just hearing it and some people work better like that.” (Melanie)

“You can actually see how it’s done so you might actually be able to do it again in the future. You don’t just have to read how things have been working; you can see how they’re working as well. You get deeper understanding if you can see and hear about it.” (Karen)

The students indicated that watching how to conduct a process helped their learning. While the multimodal content in this video was not specific to the students’ investigations, it helped them reflect on the procedures they could apply in their own investigations. By deliberately choosing the visual scaffold, the teacher drew on her video-specific ICT-TPACK to link with students’ preparations to conduct an independent investigation.

Digital Video Use and the ICT-TPACK framework

The teachers in our examples developed an awareness of the multiple affordances and constraints that videos offered to enrich their teaching and support their students’ learning, such as helping students to focus on overarching ideas and increasing the salience of some key points. They achieved this not only based on their own knowledge of how to use digital videos and what to expect from this particular technology but also because of what they knew about their students’ skills and knowledge.

This strategic employment of teacher ICT-TPACK helped students to bridge from concept to context and to keep and focus students’ attention (Banister & Reinhart, 2011). The teachers’ awareness and consideration of ICT-TPACK led them to make deliberate decisions to connect artifacts, tools, and people in line with their knowledge of where students required help and what activities would lend themselves to supporting the learning of their particular group of students. Table 3 shows how the two teachers’ video specific science pedagogy was explored using the ICT-TPACK framework from Table 2.

An examination of Tina’s teaching, in the first episode, for example, showed that she made use of digital videos as a formative assessment tool to promote student understanding of how scientists work. By applying differentiated scaffolding (Tabak, 2004) and using a different mode of sharing knowledge, Tina exemplified her ICT-PCK. The content knowledge Tina wanted her students to consider was about how scientists work. Tina’s ICT-TK related to her knowledge about the digital video cameras she had access to. She also considered that the videos were easy to produce, review, upload, and view.

Table 3
Tina's and Cindy's ICT-TPACK Framework

ICT-TPACK Components	Component Descriptors	Tina's and Cindy's ICT-TPACK
ICT-TK	Knowledge of software and hardware, including how to access, install, remove, create and/or archive digital material	<p>Flip video cameras - Teachers and their students knew how to use them and upload material online.</p> <p>YouTube videos - teachers and students knew how and where to access relevant examples</p>
CK	What is known about a given subject	<p>Not all science processes are easily observable (evaporation, heat exchanges)</p> <p>Scientists conduct their investigations in a specific way</p>
PK	Teaching methods and processes	Scaffolding supports meaning making and knowledge construction
PCK	Pedagogy specific to a particular subject matter or content	Distributed scaffolding to promote learning how scientists work, support peer and teacher assessment and support the learning of science vocabulary and symbols, and visualization processes.
ICT-TCK	Knowledge of how content and specific ICT technology may be related, for example, how digital video technology affords new ways of representations	<p>Teacher video recording student explanation of their ideas</p> <p>Teacher use of the water cycle video that used a combination of diagrams, symbols, and images to support the idea that scientific discourse is multimodal</p> <p>Teacher use of the Target video showing how to conduct experiments.</p>
ICT-TPK	Knowledge of the existence of ICT specific technologies including how they can be used and how teaching may change as a result of using them	<p>Teacher recording knowledge on video to provide students the opportunity to practice use of scientific language;</p> <p>Teachers' easy access to visually powerful information to shape and review ongoing teaching.</p> <p>Teachers' deliberate use digital video to support the multimodal construction of knowledge (video on evaporation, water cycle video) and reaffirm ideas about how to conduct experiments (Target video) placed in easily accessible places (class blog).</p>

Her PCK underpinned Tina's pedagogical choice to ask her students to conduct peer interviews, to obtain an authentic yet less formal insight into students' knowledge and attitudes about how scientists work. The teacher related her ICT-TK with her pedagogical knowledge of formative assessment and what she knew about her students in deciding to use digital video as a tool to facilitate students talking about and recording their ideas. Her ICT-TPACK in this case usefully describes the confluence of those choices and decisions to use digital video to record and review students' ideas about scientists' work.

This analysis draws attention to the significant roles teachers play in constructing settings that are conducive to ICT support of subject-specific learning. The science ideas teachers want their students to learn present unique challenges and opportunities so students can make links to the everyday and the range of vocabulary and representations used in a topic. The teachers in our study employed their ICT-TPACK in support of their students' learning to use digital videos as an effective means of distributed scaffolding learning.

Discussion

When teachers provide their students with opportunities to experience inquiry in different contexts and under different circumstances, including those supported through ICTs, they offer opportunities for students to engage in activities that can lead to more autonomy and agency (Linn, Clark & Slotta, 2003). In this article, the focus on teachers' TPACK, specifically, ICT-TPACK, allowed us to identify and investigate how the use of the digital video can scaffold learning in science classrooms.

Through this construct, we were able to address Graham's (2011) challenge to provide a more specific analysis of the nature of technology integration and obtain a better understanding of the relevancy of particular pedagogical approaches over others in ICT-based teaching and learning contexts. Teachers' pedagogical knowledge construction is bounded and framed by subject-specific pedagogical needs. These need to be considered, particularly, when considering what technology can add to teaching specific content.

The four episodes were concerned with different science content and understanding, including procedural scientific knowledge (how to conduct fair testing), the nature of science (what it means to think like a scientist), and content knowledge (the water cycle). While both teachers shared the same general teaching plan, their teaching approaches differed in ways that reflected their knowledge and understanding of their students, as well as their experience with the use of digital videos.

Videos were used as scaffolds to practice science talk and to track student progress. They were used to support student thinking about skills and processes and to help students think about their own science investigations. Although digital video use looked different in the two classrooms, both teachers set up and leveraged the synergy between the different forms of distributed video scaffolds and other classroom activities to facilitate student science learning.

When science teachers think about and plan for the distribution of scaffolds, they can optimize the affordances of digital video (i.e., its multimodal nature and ease of use) to stimulate, support, and represent students' learning. The possibility to capture, see, and hear students' voices and their ideas and exploit the multimodality of digital videos allowed the teachers to become more involved with developing students' science ideas when they were practicing a specific language through the power of visualization (Hung, 2009).

Science symbols, expressions, and cultural tools used in the videos the teachers selected for the students to watch were relevant to students' lives and practices (Niesyto, 2000) while supporting understanding and practices in science. The teachers' careful orchestration of their ICT interventions using digital videos was built on their ICT-TPACK (Angeli & Valanides, 2009) that helped them to explore the depths of content- and context-related challenges and exploit opportunities for their students to learn science.

Implications and Conclusion

Teaching with ICTs such as digital videos requires that teachers identify the pedagogical and content opportunities and challenges involved in a topic and ways the affordances of digital videos might address these. Through the sophisticated blending of knowledge, skills, and values and by drawing on their ICT-TPACK about digital video use, the teachers in this study were able to transform their teaching to provide a variety of scaffolds for student learning. They achieved this by considering content, pedagogy, and technology as both opportunities and challenges.

Illuminating what is distinctive about using digital videos in primary science as contextualized in these episodes of teacher scaffolding, shows how this ICT can afford rich and effective teaching-learning opportunities. These examples can also renew attention to the research and practice around using digital video with its affordances and opportunities specific to science teaching. Identifying the components of ICT-TPACK can assist teachers in making explicit the tacit issues often taken for granted in ICT-rich teaching and learning environments. Teachers can then consider the different instructional opportunities relevant to different teaching goals and context.

This study prompts three implications for educators and teacher educators. First, teachers can benefit from engaging in a meta-analysis of their teaching beliefs, practices, and attitudes when they plan for their students' learning. They can identify relevant strategies, opportunities, and the consequences of using ICTs in their science classrooms. Teacher beliefs and attitudes about the relevance of using ICTs to promote student learning in the classroom have, in fact, been found to have the most impact in facilitating successful ICT-integrated teaching practices (Ertmer et al., 2012). Such an analysis can enhance teacher awareness of how ICTs can promote learning, expand learning experiences, help students relate science to their own experiences, enable data collection, enhance self-management, and promote the communication of scientific ideas. The ICT-TPACK framework goes some way toward facilitating and supporting teacher meta-analyses and can be considered for teacher and teacher educator use.

Second, teachers need support if they are to identify how and when ICTs can contribute to problem solving, finding answers or communicating ideas as part of students learning activity. Time must be committed for regular reflection, to develop familiarity with a particular ICT and consider where and when it could be used to support the teaching and learning of a particular scientific idea. When teachers feel confident and have spent time considering, planning, and preparing for teaching, they are able to identify appropriate tasks where ICT provides support or opportunities for science learning. Teacher educators should highlight these aspects to beginning teachers so they learn how to incorporate them into their practice.

Finally, ICTs afford new possibilities for teachers, but these affordances need to be used to support pedagogical strategies that can bring about successful learning experiences for students. The key is to provide opportunities for students to apply their developing science skills and knowledge. ICTs that support learning tasks with multiple possible

solutions and opportunities to publicly share, illustrate, and manipulate findings can provide rich opportunities for students to become more active in and responsible for their learning.

As demonstrated in our study, the ICT-TPACK framework can provide an analytical and yet pragmatic tool in addressing the complex interrelationships between pedagogy, technology, and content. Consequently, it can provide teachers and teacher educators with ways to raise the critical awareness needed for teachers to reflect on their practices, thereby offering the critical, collaborative opportunities needed to foster students' science learning.

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Author Notes

Kathrin Otrell-Cass
Aalborg University
e-mail: cass@learning.aau.dk

Elaine Khoo
The University of Waikato
e-mail: ekhoo@waikato.ac.nz

Bronwen Cowie
The University of Waikato
e-mail: bcowie@waikato.ac.nz

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