Unpacking TPACK and students' approaches to learning: Applying *knowledge in pieces* to Higher Education teaching and learning

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This conceptual paper considers how the TPACK (technological, pedagogical and content knowledge) framework (Mishra & Koehler, 2006) can be used to gain an understanding of technology use in teaching and learning. For technology to enhance traditional teaching and learning, TPACK itself may require a tighter definition. We consider the effects of incorporating technology on both teachers' knowledge and students' approaches to learning. The intention is to look deeper into the TPACK construct and to view it from an alternative theoretical perspective. diSessa (1988) proposed a 'knowledge in pieces' theoretical approach that enables a finer-grained scrutiny of knowledge. This theoretical perspective considers knowledge to consist of small elements or 'resources'. We propose that 'knowledge in pieces' may help provide a better, more nuanced understanding of both TPACK and how technology-driven contextual change can affect learning. We conclude by outlining some implications of this theoretical perspective for future empirical research.

Keywords: Teaching; learning; TPACK; knowledge in pieces; teachers' knowledge; technology.

Introduction

Teaching in higher education requires the use of many different types of knowledge. This knowledge is diverse and includes both content and pedagogical knowledge. In recent times a new type of knowledge has been attracting attention, that of technological knowledge. Mishra and Koehler (2006) provide a framework for considering the integration of these types of knowledge that they refer to as TPACK (technological pedagogical and content knowledge). They describe TPACK as "an emergent form of knowledge that goes beyond all three components" (Mishra & Koehler, 2006, p. 1028). The implication is that this new form of knowledge is greater than its constituent parts. Angeli and Valanides (2009) consider TPACK to be an emerging type of knowledge that still needs a tighter definition. Furthermore, they question whether TPACK is a distinct/unique body of teachers' knowledge, constructed from other forms of knowledge, or whether TPACK is the integration of existing forms of knowledge.

The use of technology in higher education is largely accepted to be an integral and expected part of the student experience. This paper looks at the implications of applying a TPACK framework to teaching and how

technology can affect students' approach to learning. We look at how teachers in higher education can incorporate technology effectively into their teaching and how technology can be utilised to shift the context of learning to affect the learning process. To investigate the implications of technology in teaching and learning, a 'knowledge in pieces' perspective will be suggested as a useful theoretical lens.

Knowledge in pieces

The way the human mind works, and how knowledge is created, stored and used, remains elusive. One traditional view is that of 'schema'; a theory that suggests that as knowledge is acquired it is abstracted and stored ready for use at another time (Sawyer, 2006). When presented with a new problem or situation, the mind locates an appropriate schema to make sense of the situation. This theory suggests that individuals have stable and coherent states of knowledge; once a schema has been created it is available at all times. While helping to explain much about how thinking and knowing takes place, this view does not explain how some knowledge appears to be available in one context, but not available in another.

diSessa (1988) introduced the theory that knowledge comprises many small, fine-grained elements that activate, or do not activate, depending on context. These elements, which diSessa describes as "phenomenological primitives" (p-prims), appear self-evident to an individual and require no explanation. Considering knowledge at a much finer grain-size provides the possibility of explaining how an individual can hold opposing knowledge positions without noticing any problems caused by the conflict. For example, one piece of knowledge that an individual may hold is that motion requires the continued application of a force (I push a cup across a table and it moves, when I stop pushing it stops); the same individual can also hold another piece of knowledge which states that motion does not require the continued application of a force (I toss a coin in the air and it continues to move after I have let it go) (diSessa, 1993). These two elements of knowledge are in conflict. They are, however, often held simultaneously without the conflict being noticed. The context has changed (pushing a cup versus tossing a coin) and hence different knowledge elements are activated. The 'knowledge in pieces' theory has been used to provide insights into various issues in higher education, such as transfer (Wagner, 2006), pedagogy (Goodyear, Markauskaite, & Kali, 2009) and epistemology (Hammer & Elby, 2002). We suggest that this theory may also provide a better, more nuanced understanding of TPACK guiding the understanding of technology use in higher education.

Higher Education: Teaching with technology

Teachers' knowledge of technology, and how technology is integrated into the curriculum, has become a major focus of research. Graham, Burgoyne, Cantrell, Smith, Clair, and Harris (2009) state that knowledge related to the effective use of educational technologies has become widely recognized as an important aspect of an educator's knowledge-base for the 21st Century. Technology, in this context, incorporates more than the use of ICT tools; it is the creation of complex relationships between artefacts, users, tools, and practices (Koehler & Mishra, 2005). Higher education institutions are focusing on technology-facilitated learning environments to improve the quality of the teaching process. Ertmer (2005) reports that technology is now considered to be an integral part of providing a high-quality education. Further studies indicate that the use of technology in education demands that teachers develop their knowledge of technology and hence become more able to integrate a range of technology tools effectively into their teaching (see Goodyear, Jones, Asensio, Hodgson, & Steeples, 2005; Yunus, Kasa, Asmuni, Samah, Napis, Yusoff, Khanafie, & Wahab, 2006; Zenios, 2006; Strampel & Oliver, 2007).

Mishra and Koehler (2006) stressed that, as well as being technology users, teachers should gain a proper understanding of the technology. This implies an understanding of how technology can be used to teach particular content and how content could be altered to make teaching with technology more meaningful for learners. Mishra and Koehler further posit that more effective and constructive teaching may rely on generating an understanding of the factors that make particular concepts difficult or easy to learn. This understanding, based on the integration of technological, pedagogical and content knowledge, could lead to innovative ways of incorporating technology into existing teaching practices.

Despite attempts to understand how TPACK is formed, there still appears to be a disagreement about the definition and nature of the combined knowledge (see Koehler & Mishra, 2009; Angeli & Valanides, 2009; Cox & Graham, 2009). Harris, Mishra, and Koehler (2009) suggest that TPACK is formed through many interactions between the component knowledge types. By fluently integrating different knowledge elements and by gaining an understanding of the interrelationships between the knowledge types, teachers may be able to switch

between, and integrate, the three component knowledge areas of TPACK according to the context.

Considering the three component knowledge areas that make up TPACK (technology, pedagogy and content) as separate and isolated areas of knowledge, it is hard to understand how the combination of these areas can produce anything more than the simple integration of existing knowledge. However, considering each of these knowledge areas as being encoded in the form of smaller knowledge elements that may or may not be activated depending on context, provides the possibility of understanding how the combination can become greater than the parts. When some knowledge elements in one of the components of TPACK become activated, they may influence the activation of other knowledge elements from another component of TPACK.

Teaching with technology may change the traditional role of the teacher. Gonzalez (2010) outlines four roles that a teacher needs to appropriate when teaching with technology. These roles are: provider of online information, creator of communication spaces, facilitator of discussions, and designer of "knowledge building" environments. These roles may require specific knowledge, much of which is based on traditional pedagogical and content knowledge that needs to be integrated with technological knowledge. Seeking out the technological, pedagogical and content 'p-prims', and looking for ways that these knowledge elements interact, may provide a starting point that leads to a better understanding of teachers' knowledge.

Higher Education: Learning with technology

Technology is often considered to be an additional tool, available to students to help with their learning. Selwyn (2007) provides an insight into the usefulness of technology from the students' perspective. Rather than embracing technology as an effective learning tool, students take a more pragmatic approach to their learning, concentrating on those aspects that are most likely to help them reach their goal - a good grade (Selwyn, 2007). Unless technology performs a useful role in this respect, it may remain an adjunct. One way technology can help towards the students' goal is by changing the context of learning.

It is thought that learning may be affected by the context in which the learning is taking place; individuals approach similar problems in different ways when in different settings. Lave (1988) shows evidence that when 'real life' problems are presented in school, the 'situation' part of the problem is generally ignored, or treated as some kind of *red herring*, designed to disguise the real problem. However, when a similar problem is encountered in real life, the situational context is not only recognised, it is used as an integral part of finding a solution (Lave, 1988). Carraher, Carraher, and Schliemann (1985) found a similar example of this mismatch of knowledge. They reported that knowledge became unavailable in certain situations; street sellers could make complex mathematical calculations when trading but were unable to perform similar calculations in a school setting. Interpreting this with a 'knowledge in pieces' theoretical lens, suggests that different knowledge elements are activated in the different contexts.

Technology may provide the possibility of changing a learning context, which may in turn help students activate different knowledge elements. Rather than limiting technology use in higher education to that of enhancing an existing pedagogical style, technology could also be used to change the context of learning. To understand the effects of changing the learning context, it may be helpful to investigate the process of learning and how that process can be varied when technology is introduced. Viewing the process of learning using a 'knowledge in pieces' theoretical approach may enable the identification of specific fine-grained knowledge elements (elements that are self-evident to the individual) that become activated. Discovering these knowledge elements and understanding the factors that enable them to become activated, and in which context, may provide a key to a better understanding of how context, and therefore technology, can change learning.

Implications for future empirical research

Gaining a better understanding of how technology affects teachers and teaching may provide an insight into effective use of technology in higher education. The use of technology as an integral part of the process of learning may also affect learners by varying the context of learning. A 'knowledge in pieces' theory provides a lens through which this can be viewed.

Further research will be necessary to investigate these two areas. Following on from work by diSessa (1993), Hammer and Elby (2002), Wagner (2006), and others, we suggest the following ways forward:

1. Explaining the nature of TPACK.

To gain a better understanding of how teachers utilise different knowledge types and how different knowledge elements are activated, it may be necessary to consider the 'thinking' process when teaching. Investigating a thinking process is challenging; knowledge elements, while self-evident to an individual, remain elusive to others. These elements may be detectable from observing teachers and also by undertaking content analysis of teachers' activities (such as planning and teaching sessions), employing techniques such as 'thinking aloud'. Observing differences in pedagogical and content 'p-prims', when technological 'p-prims' are activated, may lead to a better understanding of the nature of teachers' knowledge.

2. Understanding how technology can change the context of learning and how that change can affect student thinking.

To gain a better understanding of how students' thinking changes as context changes, it may be necessary to investigate the 'thinking' process during learning and how that process changes when a student is learning in different contexts. As above, investigating a thinking process is challenging and the challenge is increased by the necessity to study the process in different contexts. Observing students working in small groups may provide an insight into their thinking process as they articulate their thoughts to other members of the group. By analysing students' speech, while they are working on similar problems in different contexts, it may be possible to detect different knowledge elements being activated in the different contexts. Gaining a better understanding of how students learn, when technology has affected the context of learning, could be used to develop better technology-driven learning environments.

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