Epistemological and Methodological Issues for the Conceptualization and Development of ICT-TPCK

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ABSTRACT

In this paper, several issues regarding the epistemology of technological pedagogical content knowledge (TPCK) are first raised for the purpose of clarifying the construct. Specifically, the transformative and integration views are juxtaposed for exploring the epistemology of TPCK. The integrative view is rejected and the transformative view is adopted concluding that TPCK is a unique body of knowledge that is constructed from the interaction of its individual contributing knowledge bases. Then, ICT-TPCK is introduced as a strand of TPCK, and is 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 represented by teachers can be transformed and taught more effectively with technology in ways that signify its added value. Technology Mapping is proposed as a situative methodology for the development of ICT-TPCK. Future research efforts with the intent to improve or further develop the framework discussed herein will have important implications for both research and practice.

KEYWORDS: *Technological pedagogical content knowledge, Teaching with computers, ICT-TPCK*

INTRODUCTION

The lack of theory and conceptual frameworks to inform and guide research in the area of teaching with technology is a major weakness in the educational technology literature (Angeli & Valanides, 2005; Mishra & Koehler, 2006; Selfe, 1990). As Selfe (1990) well stated "until we share some theoretical vision of this topic, we will never glimpse the larger picture that could give our everyday classroom efforts direction and meaning" (p. 119). In view of recognizing the lack of a sound theoretical orientation to guide teacher preparation in technology integration, researchers initiated during the last five years systematic research efforts for the purpose of developing theory and models upon which to ground research in the area of teacher cognition about technology integration (Mishra & Koehler, 2006). These researchers advocate the need to develop a new body of knowledge that constitutes an extension of Shulman's (1986, 1987) pedagogical content knowledge (PCK) into the domain of teaching with technology. This extended view of PCK is offered as a framework for revitalizing the study of teacher knowledge and for collecting and organizing data on teacher cognition about technology integration.

A few conceptions, proposed mostly by American researchers, of how to extend PCK in the domain of teaching with technology exist in the literature under different labeling schemes. For example, Slough and Connell (2006) used the term technological content knowledge, and Mishra and Koehler (2006) the term technological pedagogical content knowledge (TPCK) – a comprehensive term that has prevailed in the literature. While the authors of the present paper do acknowledge the important work that has been done on TPCK thus far, here they seek to raise important theoretical, epistemological, and methodological issues relating to TPCK. It is also stated from the beginning that the present study will mainly focus on ICT (Information and Communication Technologies), which, by and large, are currently at the center of scientific interest, exploration, and investigation. Thus, the term ICT-TPCK will be used herein for denoting TPCK that is exclusively related to information and communication technologies. In particular, the paper will provide answers to the following two questions: (a) Is ICT-TPCK a unique body of knowledge or a body of knowledge that is made of other teacher knowledge bases? (b) How is ICT-TPCK developed?

PCK AS A CONCEPTUAL BASIS

The concept of PCK was initially introduced by Shulman (1986) who insisted that research on teaching and teacher education did not pay enough attention to the content of the lessons taught. PCK "identifies the distinctive bodies of knowledge for teaching" (Shulman, 1986, p. 8) and refers to teachers' interpretations and transformations of subject matter knowledge for facilitating student learning. The construct of PCK constitutes a special amalgam of content and pedagogy, and is the kind of knowledge that separates an expert teacher in a subject area from a subject area expert. Shulman (1986, 1987) described PCK as the ways content, pedagogy, and knowledge of learners are blended into an understanding about how particular topics to be taught are represented and adapted to learners' characteristics, interests, and abilities. Scholars, like Cochran, DeRuiter, and King (1993), have extended the concept of PCK by including in it some additional elements. They defined PCKg as "a teacher's integrated understanding of four components of pedagogy, subject matter content, student characteristics, and the environmental context of learning" (Cochran et al., 1993, p. 266), and emphasized the amalgamated nature of PCK, as the result of the concurrent development of these four components.

TPCK: AN EXTENDED VIEW OF PCK

PCK constitutes the conceptual basis for Mishra and Koehler's (2006) conceptualization of TPCK that is conceptualized as a situated form of knowledge deeply rooted in the interactions of subject matter, pedagogy, and technology. Koehler, Mishra, and Yahya (2007) stated that TPCK is a situated form of knowledge that is required for the intelligent uses of technology in teaching and learning. "At the heart of TPCK is the dynamic, transactional relationship between content, pedagogy, and technology. Good teaching with technology requires understanding the mutually reinforcing relationships between all three elements taken together to develop appropriate, context-specific, strategies and representations" (Koehler et al., 2007, p. 741). Koehler et al.'s (2007) conceptualization of TPCK considers all possible interactions between any two elements, namely, Pedagogical Content Knowledge, Technological Content Knowledge, and Technological Pedagogical Knowledge. While Koehler et al. (2007) do emphasize that students need to be engaged in rich design activities in order to understand the interrelationships among content, pedagogy, and technology, the authors of this paper do believe that Koehler et al.'s (2007) conceptualization of TPCK needs further theoretical clarity. It is argued that if TPCK is to be considered as an analytical theoretical framework for guiding and explaining teachers' thinking about technology integration in teaching and learning, then TPCK's degree of precision needs to be put under scrutiny. The degree of precision of a construct refers to the discriminating value of the construct and has important implications for its development and assessment.

For example, it is not clear from Koehler et al.'s (2007) empirical findings whether TPCK is a distinct form of knowledge or whether growth in TPCK simply means growth in any of the related constructs (i.e., Pedagogical Content Knowledge, Technological Content Knowledge, Technological Pedagogical Knowledge, or even the initial constructs of Pedagogy, Content, and Technology). Furthermore, the boundaries between some components of TPCK, such as for example what they define as Technological Content Knowledge and Technological Pedagogical Knowledge, are fuzzy indicating a weakness in accurate knowledge categorization or discrimination, and, consequently, a lack of precision in the framework. Furthermore, TPCK in its current form appears to be too general, primarily because it does not deal explicitly with the role of tool affordances in learning. Essentially, while Koehler et al. (2007) do assert that at the heart of TPCK is the dynamic, transactional relationship between content, pedagogy, and technology, and that "good teaching with technology requires understanding the mutually reinforcing relationships between all three elements taken together to develop appropriate, context specific, strategies and representations" (p. 741), the framework does not make explicit the connections among content, pedagogy and technology.

While it is perfectly understood that the preference for a general model might be directly related to its potential wide applicability in different contexts, the lack of specificity is problematic, because the very important issue of how tool affordances can transform content and pedagogy is not addressed. Also, the framework in its present form does not take into consideration other factors beyond content, pedagogy and technology, such as, for example, teachers' epistemic beliefs and values about teaching and learning that may be also important to take into account. This simplified or general view, one might argue, may lead to possible erroneous, simplistic, and naïve perceptions about the nature of integrating technology in teaching and learning.

THEORETICAL AND EPISTEMOLOGICAL CONSIDERATIONS ABOUT TPCK

The unresolved issue that researchers neglected to consider about TPCK is whether TPCK is a distinct or unique body of knowledge that is constructed from other forms of teacher knowledge - the transformative view, or whether TPCK is not a distinct form of knowledge, but is integrated from other forms of teacher knowledge "on the spot" during teaching - the integrative view. Each of these views has important research implications about the nature of the questions to be raised and the data to be collected. For example, research questions framed from the transformative view focus on TPCK itself, the methodology is designed to obtain data about TPCK, and the conclusions are made in terms of TPCK. In the same way, research questions framed from the integrative view focus on the contributing forms of teacher knowledge, the methodology is designed to obtain data about the contributing knowledge bases, and conclusions are reached in terms of them. In other words, the data do not show evidence of TPCK, instead they relate to TPCK's constituent components.

From the current body of literature on TPCK, it seems that most researchers believe that growth in any of the related constructs (i.e., content, technology, pedagogy) automatically contributes to growth in TPCK (Koehler et al., 2007). The authors of this paper have extensively tested this hypothesis. During the last five years, they conducted a number of empirical investigations regarding the educational uses of computer technology, and based on their findings they concluded that growth in the related constructs does not automatically mean growth in TPCK. These findings suggest that TPCK itself is a body of knowledge different from its constituent components (Angeli & Valanides, 2005, in press; Angeli, 2005; Valanides & Angeli, 2007, 2008). Based on the results of their empirical investigations, the authors suggest that TPCK is a distinct body of knowledge that can be developed and assessed. This body of knowledge goes beyond mere integration or accumulation of the constituent knowledge bases, toward transformation of these contributing knowledge bases into something new. Thus, the authors do not support the integrative view, since growth in the individual contributing knowledge bases without specific instruction targeting exclusively the development of TPCK did not result in any growth in TPCK (Angeli & Valanides, 2005; Angeli, 2005; Valanides & Angeli, 2007), indicating that TPCK is a unique body of knowledge.

FROM TPCK TO ICT-TPCK

ICT-TPCK is conceptualized as a strand of TPCK, and TPCK, as discussed herein, serves as an initial conceptual basis for ICT-TPCK. Thus, ICT-TPCK's constituent knowledge bases include TPCK's three contributing knowledge bases, namely, subject matter knowledge, pedagogical knowledge, and technology (restricted to ICT in this case), and two additional elements, namely, knowledge of learners' content-related difficulties and knowledge of the context within which learning takes place. The two additional elements were added taking into consideration research evidence from studies with in-service teachers (Valanides & Angeli, 2008). This evidence indicated that teachers during teaching with technology drew upon their knowledge relating to their students' content-related difficulties as well as knowledge of the intricacies of the relevant context, i.e., what worked and what did not in their classrooms, and how they believed they needed to teach for their students to learn. ICT-TPCK is defined 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 represented by teachers, can be transformed and taught more effectively with ICT, in ways that signify the added value of technology.

TECHNOLOGY MAPPING: A SITUATIVE METHODOLOGY FOR DEVELOPING ICT-TPCK

Technology Mapping (TM) has been gradually developed in a number of design-based research studies during the last five years (Angeli & Valanides, 2005, in press; Angeli, 2005; Valanides & Angeli, 2007, 2008). The ID model shown in Figure 1 is offered as a participative approach and a tool that teachers can use in order to deal with technology design problems. In essence, TM is an interaction technique that seeks to identify the dynamic transactions among all constituent knowledge bases of ICT-TPCK, while at the same time it places emphasis on the situated nature of teachers' thinking and the critical role that teachers' understandings of their context and their students play in their instructional decisions.

As shown in Figure 1, first, teachers are asked to think about a specific content domain, and based on their experiences, to indicate their difficulties in making the most challenging aspects of the domain teachable to students, in connection with students' content-related difficulties. In the case of inexperienced pre-service teachers, teacher educators can provide them with a variety of examples from the literature on learners' alternative conceptions and the process of conceptual change. Thus, as shown in Figure 1, initially, teachers identify various topics within a specific content domain that are challenging to teach and learn. Subsequently, for each topic, teachers associate relevant content (represented as circles in Figure 1) and tentative objectives based on learners' related alternative conceptions that need to be addressed. The nested design of the diamond in Figure 1 represents the iterative ID decision process that teachers are engaged in, in order to decide how they should transform the content to make it teachable to their students. In doing so, teachers need to first decide how tool affordances can be used to transform content into powerful representations (upper part of the diamond), and how to tailor these representations for the specific needs of their students and use them by employing various pedagogical strategies in their respective classrooms (lower part of the diamond).

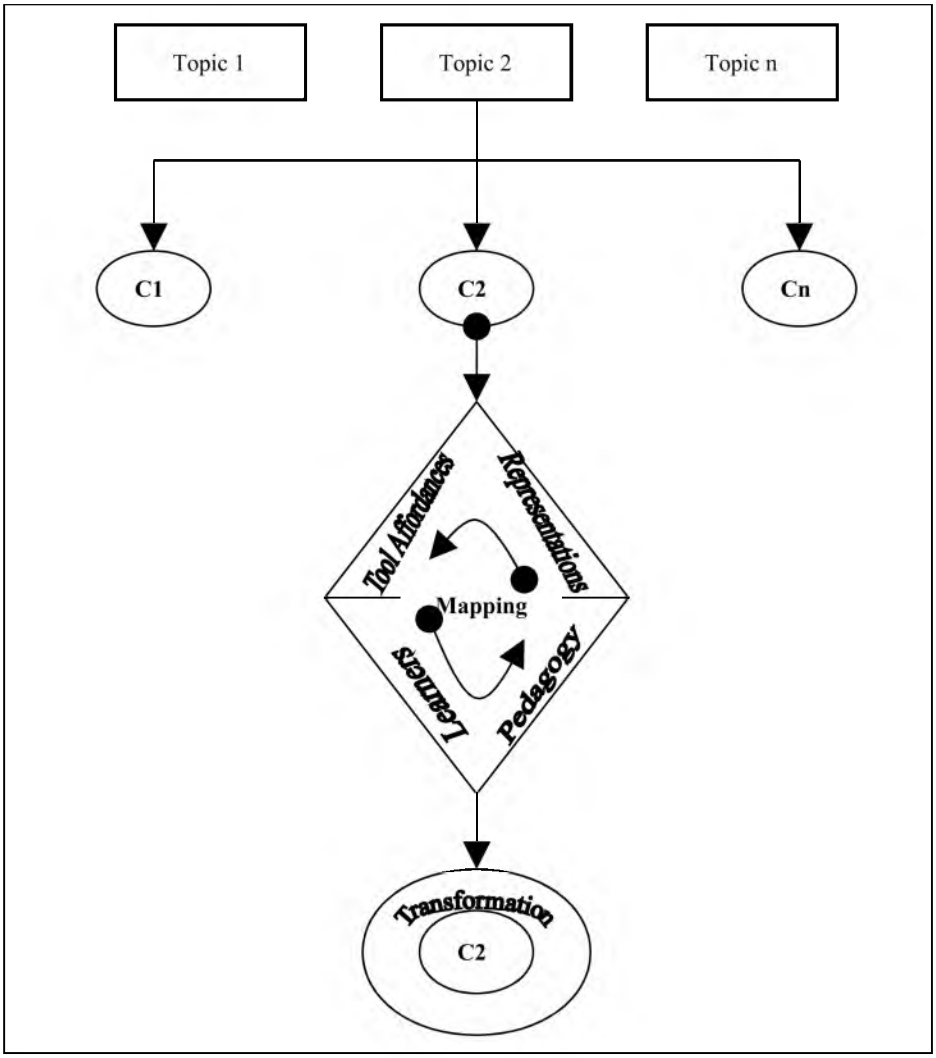

Figure 1. *A situative ID model for the design of technology-enhanced learning*

Mapping tool affordances onto content and pedagogy is at the heart of the TM approach. Mapping refers to the process of establishing connections among the affordances of a tool, content, and pedagogy. An example of how the connections among software affordances, content and pedagogy can be made explicit to teachers is presented in Table 1. The entries in Table 1 are not meant to be exhaustive but illustrative of how the connections can be made. According to Angeli and Valanides (2005), Angeli (2005), Valanides and Angeli (2007), it is very important that teacher educators explain in detail who - the teacher or the learner or both - will be using these powerful representations in the classroom, for what purposes, and why. The outcome of this complex instructional decision process will be a series of powerful pedagogical transformations, as depicted in the double-round circle in Figure 1.

CONCLUDING REMARKS

The present paper first raised and discussed several epistemological issues regarding the construct of TPCK for the purpose of clarifying it, and, thereafter, introduced ICT-TPCK as a strand of TPCK and proposed TM as a model for its development.

Table 1. *Mapping software affordances onto content representations and their pedagogical uses*

Software Affordance	Content Representations	Pedagogical Uses
Pictures/symbols in libraries	Visualization of concepts	• Students use pictures and symbols to observe, express themselves, explain, and make their thinking/understanding visible. • Teachers can use pictures to explain something, to create cognitive conflict, to present discrepant events, to initiate discussion about a topic.
Pictures are paired with their corresponding words	Textual and pictorial representations	• Students' early reading skills begin to emerge and young students "can write" their own stories.
Visual association between a pictorial view and writing view	Images get dynamically transformed into their equivalent written expressions and vice versa	• Learners explore the connections between images, words and their meaning by switching from the pictori al view to the writing view and vice versa.
Record and hear sound	Auditory representations	• Students and teachers can record their ideas. • Students can hear any text read aloud, strengthening word recognition and comprehension.
Hyperlinks	Multimodal representations: • auditory • textual • visual • interactive	1. Students can "travel" to the Internet to read about something, to hear about something, to view a video, to explore different points of view, to run a model or simulation, or even to visit a virtual museum.

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