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Colloquium

TPCK framework: assessing teachers' knowledge and designing courses for their professional development

Djordje M. Kadijevich

Address for correspondence: Djordje Kadijevich, Megatrend University, Goce Delceva 8, Belgrade 11070, Serbia. Email: djkadijevic@megatrend.edu.rs; Mathematical Institute of the Serbian Academy of Sciences and Arts, Kneza Mihaila 36, 11001 Belgrade, p.p. 367, Serbia. Email: djkadij@mi.sanu.ac.rs

Introduction

Although the use of technology can empower teaching and learning, it is rarely used in classrooms (Ruthven, 2009). A major reason for that unfavorable state may be found in the fact that teachers lack sophisticated knowledge to support effective technology integration. This knowledge is indeed sophisticated as it, among other issues, calls for complex interplay involving three types of knowledge: content knowledge to teach, pedagogical knowledge to apply, and technology knowledge to empower the previous two. Because of this interplay, successful technology integration clearly requires teachers to develop a new body of knowledge, known under the name *technological pedagogical content knowledge* or just TPCK (Angeli & Valanides, 2009).

Studies on TPCK can help researchers understand the complex interactions among content, pedagogy, technology, as well as learner and context. They also can be used for assessing teachers' knowledge of technology integration and designing courses for their professional development to improve this integration. Having in mind the second direction, this study used the TPCK framework to find types of knowledge that need be better covered by teacher professional development.

Method

The study used a sample of 45 teachers of introductory PASCAL programming in gymnasiums across Serbia (about one-third of all such teachers in Serbia). This introductory programming, given in Grade 11 fall semester, comprised of the following contents: variables, linear, branch and loop structures.

This study used a short questionnaire assessing demographic information regarding gender, country region and number of times this programming was taught. Twenty-seven participants were females, while the majority of them (35) had taught this programming three or more times.

The participants also responded to a seven-item TPCK questionnaire:

I would realize my teaching of programming better if I knew more about:

1. concepts and methods of programming,
2. environments for programming i.e. program development,
3. different teaching methods,
4. the use of educational technology for presenting main programming contents,
5. the use of educational technology for implementing different teaching methods,
6. teaching methods for the work with different programming contents,
7. the use of educational technology for implementing teaching methods for the work with different programming contents.

This TPCK questionnaire was given in Serbian as a Likert scale with five points ranging from *fully agree* (5) to *fully disagree* (1). The reliability (Cronbach's alpha) of the questionnaire was 0.88. Note that its representativity (Kaiser, Mayer & Olkin's measure) was 0.97.

Results

Correlations among responses to seven items ranged from 0.231 (between TK and PCK, ie, items 2 and 6) to 0.770 (between TPK and TPCK, ie, items 5 and 7) with 10 correlations higher than 0.50. A two-component factor analysis revealed that the participants' seven answers would be examined as two components: one with pedagogy excluded (only CK, TK and TCK, ie, items 1, 2 and 4), and the other with pedagogy included (items 3, 5, 6 and 7). Table 1 shows the mean, standard deviation and reliability for these two components. The participants' needs for the TPCK component with pedagogy included were, on average, higher than their needs for the TPCK component with pedagogy excluded (3.45 vs. 2.71 with $r = 0.58$; $t = 5.082$, d.f. = 44, $P < 0.001$). For each of the two components, no differences were found with respect to gender, country region or number of times this programming was taught.

Discussion

As almost half of the correlations among seven domains of knowledge were above 0.50, it seems that these domains are not distinct, suggesting that the TPCK framework may be unnecessarily more complicated than it should (Archambault & Crippen, 2009). Although Schmidt *et al.* (2009) give factor structure for each of these seven domains, no study so far, to the author's reading, reported a desirable three-component structure matrix such as that presented in Table 2.

Despite possible limitations of the TPCK framework or its recent operationalizations, its simple operationalization used in this study did straightforwardly and efficiently reveal types of knowledge that need to be better covered in the professional development of teachers of introductory programming. These types of knowledge are all those that include pedagogy. This was an expected outcome for Serbia, where informatics teacher candidates receive good theoretical and practical programming knowledge, which is usually not the case with pedagogical knowledge and all knowledge types involving it according to the TPCK framework. Things may improve in in-service professional development, although the focus is typically again on content knowledge and

Table 1: Mean (M), standard deviation (SD) and reliability (α) of two TPCK components

Component	*M*	*SD*	α
Pedagogy excluded (TK, CK and TCK)	2.71	1.09	0.81
Pedagogy included (PK, TPK, PCK, TPCK)	3.45	1.04	0.87

Table 2: Desirable three-component structure matrix for seven TPCK items (hypothetical data when each domain is represented by one item)

Knowledge item	*Factor 1*	*Factor 2*	*Factor 3*
C	0.60		
T		0.75	
P			0.68
TC	0.40	0.48	
TP		0.50	0.44
PC	0.41		0.51
TPC	0.45	0.40	0.42

technological knowledge (the means for the two were 2.24 and 2.64, respectively), neglecting, for example, the important issue of using educational technology for presenting main programming contents (the mean for TCK was 3.24).

Clearly, professional development of teachers of informatics oriented toward pedagogy should deal successfully with the following three challenging areas: teaching methods for the work with different programming contents (PCK), the use of educational technology for implementing different teaching methods (TPK), and the use of educational technology for implementing teaching methods for the work with different programming contents (TPCK). In doing so, professional development should make use of visual learning environments supporting visual programming, such as PUCK (Kohl, 2008). This development may in general use a technological platform that according to the teacher's specifications assembles courses for specified content, teaching method, technological tool and learner's model. Such an advanced platform, called *ActiveMath*, has been used for the teaching/learning of mathematics (Melis, Haywood & Smith, 2006). This approach, although to a smaller extent, can be recognized in Zendler, Spannagel and Klaudt (2011), where central concepts such as algorithm (ie, content) are combined with central process concepts such as problem solving (ie, pedagogical approach).

Conclusion

This study used the TPCK framework to find types of knowledge that need to be better covered by teacher professional development. Despite possible limitations of the TPCK framework and its operationalization used in this study, it was found that the participants' needs for the TPCK component with pedagogy included were, on average, higher than their needs for the TPCK component with pedagogy excluded. The professional development of teachers of (introductory) programming should thus primarily be oriented towards pedagogical issues, which would include the following three challenging areas: teaching methods for the work with different programming contents (PCK), the use of educational technology for implementing different teaching methods (TPK), and the use of educational technology for implementing teaching methods for the work with different programming contents (TPCK). Three studies in mathematics and computer science education reported in this research note may strengthen educators in coping with these challenging areas.

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