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TPACK addressed by trainee teacher educators' documentation work

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In this paper we study the forms of technological pedagogical content knowledge (TPACK) addressed by trainee teacher educators' documentation work for teachers. The study took place in the context of an in-service program during the trainees' engagement in their practicum fieldwork activities. The documentational approach of didactics and the TPACK framework were combined to identify categories of documents and operational invariants.

Keywords: Documentational approach, TPACK, teacher educators' education, digital resources.

Introduction

In this paper we combine the documentational approach of didactics (Gueudet & Trouche, 2009) and the technological pedagogical content knowledge (TPACK) framework (Mishra & Koehler, 2006) to study the TPACK forms of knowledge addressed by trainee teacher educators' (TEs) documentation work (DW) in the context of their practicum. Practicum was provided shortly before the end of an in-service, reform-oriented professional development (PD) program within the Greek educational system aiming to educate TEs into the pedagogical use of digital tools in the teaching of mathematics. Recent literature reviews on TPACK (e.g., Voogt et al., 2013) identified the need for further research on the interrelation between TPACK, teacher practical knowledge, and teacher beliefs as well as the effects of PD courses in the development of TPACK. In this study, we analyse TEs' DW so as to identify possible interrelations between these elements.

Theoretical framework

Teachers' DW involves "looking for different kinds of resources, selecting/designing mathematical tasks, planning their succession, managing available artifacts, etc." (Gueudet & Trouche, 2009, p. 199). In this process, curriculum materials are not conceived as static bodies of resources that guide instruction, but rather as objects amenable to changes and modifications depending on the teacher's didactical design. Through a class of professional situations and teachers' experiences, the existing resources can be modified as documents according to the formula: Document = Resources + Usages + Operational Invariants. The term 'document' describes not only the material component of resources and the observable parts of teachers' stable behavior for a given class of situations (called usages), but also the implicit knowledge 'piloting' their usages, i.e. the operational invariants.

In order to describe the knowledge needed for integrating technology in teaching, Mishra and Koehler (2006) developed the TPACK framework taking into account the interplay between content, pedagogy, and technology: (a) Technology knowledge (TK) concerns knowledge about technical aspects of hardware and software; (b) Technology content knowledge (TCK) refers to the ways that technology can be interrelated to subject knowledge; (c) Technological pedagogical knowledge (TPK) describes a broader knowledge of technology in relation to pedagogical strategies concentrating on the knowledge of tools and its functionalities, as well as on the interrelation

between specific tools and tasks; (d) Technological pedagogical content knowledge (TPCK) describes an emergent form of knowledge that requires understanding of concepts, pedagogical techniques for communicating mathematical content in constructive ways, knowledge of students' difficulties in learning particular topics, knowledge of students' prior knowledge, and how all the above can be readdressed through the use of technology.

By analyzing the trainees' DW, the research question we aim to address is: Which TPACK forms of knowledge are targeted by the trainee TEs in their documents and which operational invariants are related to these forms of knowledge?

Methodology

The PD program we refer to was implemented in University Centers (UCs) all over Greece for 350 hours and the plan was to employ the newly trained TEs in wide-scale courses to educate groups of teachers in specific Centers for Teacher Education Support (CTES). Practicum was part of UC official structure. Its duration was 30 hours and involved: (a) observation of other teacher educators' teaching in CTES, (b) design of a 3-hour lesson for teachers in CTES under the supervision of a mentor and implementation in CTES, (c) presentation of design and implementation in UC special reflective sessions. The present study took place in the context of a UC course at the University of Athens where we had the role of academic trainers and mentors of trainees. The 16 trainee TEs were experienced, qualified secondary mathematics teachers. Our data consisted of: (1) the researchers' notes from the UC reflective sessions; (2) the trainees' designs for their lessons in CTES (scenarios, worksheets, etc.); and (3) the trainees' activity reports (i.e. templates in which trainees described aspects of their designs and their experiences from the implementation). In the first step of the analysis, under a grounded theory approach (Charmaz, 2006) we categorized the TEs' documents in relation to the TPACK forms of knowledge targeted for teachers in CTES. In the second step, in order to shed light on the interconnections between these forms of knowledge and the underlying operational invariants we triangulated the analysis of trainees' DW, our notes from the reflective sessions and the trainees' activity reports.

Results

The 16 trainee TEs' designs were categorized in two broad categories of documents concerning the targeted TPACK forms of knowledge: (1) documents prioritizing TK and TCK and (2) documents combining TPK and TPCK. Below, we provide a short description of each one of them.

Prioritizing TK and TCK: Instructive documents The documents of this category emphasize the correct use of the available technologies and how they can be interrelated to subject knowledge. This is usually evident in specific worksheets that are structured in the form of step-by-step instructions ensuring the correct use of the tools for the requested activities. For instance, one trainee TE working on an official scenario introducing linear functions through transformations of y=ax with Function Probe (FP) (Confrey, 1991-2002), designed a worksheet including instructions such as: "Table window: Fill in the 3rd column with the ratio y/x and press enter"; "Write down the resulting values and explain what they show"; "Table window: Send points to the graph"; "Graph window: Graph → graph choices → Tick 'Show transformations' → Click on the icon 'y=…' to create the graph of y=x." Common TEs' justifications for this kind of DW provided during the

reflective sessions concerned their observations in CTES that focused on: the different levels of teachers' familiarization with digital technologies; difficulties in linking the different digital representations; the official trainers' teaching model and agenda. Also, documents belonging to this category, seem to prioritize a view of teachers in CTES mainly "as students" who need to be familiarized with tool functionalities rather than a view of them as "teachers of students" who need to be engaged in reflection on how to transform the scenario for their students in school. The implementation of these documents in CTES was characterized by instructive teaching practices targeting skills' mastery and correct performance through a strict following of the worksheet. The operational invariants underlying DW of this category are related to: (a) TEs' emphasis on constraints and opportunities afforded by the context (e.g., time restrictions, technological environment); (b) TEs' observation in CTES concerning teachers' difficulties (with tools or more general) and the previous teaching model adopted by the official trainer in CTES; (c) TEs' epistemology for the teaching and learning of mathematics with technology considering the correct use of tools as a prerequisite for linking tools and content.

Combining TPK and TPCK: explanatory and facilitative documents A distinct feature of the documents included in this category is the emphasis on the P aspect of TPACK that is expressed either through 'explanatory' documents or 'facilitative' ones. Both of them are primarily based on materials designed by the TEs aiming not only to familiarize teachers in CTES with technological tools, but also to support them in conceiving pedagogical uses of these tools for their classroom teaching. However, the P aspect is targeted in different ways in each one of the above subcategories. The explanatory documents consist mainly of tasks involving the use of specific digital tools in parallel with explanations for their pedagogical value while the facilitative ones include mainly open tasks favoring exploration and teamwork.

More specifically, the explanatory documents were created by the TEs mostly through transformation of existing UC materials with the aim to explain to the teachers in CTES – from the TEs' own perspectives – issues related to the efficient integration of technology in the teaching and learning of mathematics. The design of these documents involves new didactic tools aiming to bridge the distance between the language of official resources and the language of practitioners. This kind of documents echoes a consideration of teachers "as students" who need familiarization with technology. At the same time, these documents target teachers' transition to "teachers of students" by explaining the link between tools and pedagogic aims. For instance, one TE prepared a worksheet for the teachers corresponding to an official scenario related to the study of sinusoidal function with FP. The worksheet had the form of a two-column table: in the left column, he inserted the worksheet questions, and in the second, the rationale. He engaged students in exploring the role of ρ in y=ρsinx kinesthetically by stretching the graph of y=sinx (through the "stretch tool") until coinciding with the graph of y=2sinx and y=3sinx which had been constructed. On the right column of the worksheet he explained the added value of the dynamic manipulation tools: "Study of function y=ρ*sinx," "What is the role of ρ." "Multiple representations of the relation between y=sinx and y=2sinx, y=3sinx, Table: visually, Graph: visually and kinesthetically."

The facilitative documents favor teachers' exploration of mathematical ideas, connections between different representations and collaborative work in the form of open tasks allowing TEs to confront

potential teachers' difficulties with digital tools on the spot. The design of these documents does not focus on the technological skills per se but rather how these can be incorporated pedagogically by the teachers for their classroom students. For instance, one of the facilitative documents included open tasks without any kind of instructions (even for aspects of the software). The teachers were asked to work in groups of two and provide both an algebraic and a geometrical solution for a given problem and then to discuss in groups about the potential students' approaches. Then, they were engaged in class discussion of the above findings and the added value of the software. Finally, they were asked to collaboratively design indicative questions for their students and present it in the CTES classroom. The implementation of these documents in CTES was usually characterized by teaching practices facilitating problem posing and solving, and favoring the development of meaningful material by the teachers themselves.

The operational invariants underlying DW of this category include: (a) TEs' epistemological conceptions of the ways mathematical knowledge should be approached though the use of technology; (b) TEs' observation in CTES concerning teachers' difficulties (e.g., use of tools, design of didactical materials); (c) TEs' conceptions of trainees "as students" who need particular supporting structures or pedagogical strategies (e.g., groupwork) to reinforce their TPK and TPCK.

Conclusion

The analysis showed two categories of documents concerning the targeted TPACK forms of knowledge. In each category, three kinds of documents have been identified, addressing differently the integration of technology in the teaching and learning of mathematics by the teachers. Operational invariants underlying trainee TEs' DW are directly linked to the teaching practice in teacher education contexts as well as to their epistemologies for the role of technology in the teaching and learning of mathematics and the ways they conceive trainee teachers ("as students"/"of students"). DW emphasizing the T aspect of TPACK is related to TEs' emphasis on the correct use of tools, conception of teachers "as students" and instructive teaching practices. On the contrary, DW emphasizing the P aspect of TPACK is related to trainees' conception of teachers' learning through connecting tools and pedagogic aims as well as through challenging teachers' engagement in open tasks favoring exploration and teamwork.

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