Qwerty

15/2/2020

Open and Interdisciplinary
Journal of Technology,
Culture and Education

Special issue

From the Teaching machines to the Machine learning. Opportunities and challenges for Artificial Intelligence in education

Edited by
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& Graziano Cecchinato

Publisher
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Registrazione del Tribunale di Bari
n. 29 del 18/7/2005

ISSN 2240-2950

Index

Student teachers' pedagogical reasoning in TPCK-based design tasks. A multiple case study

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DOI: 10.30557/QW000031

Abstract

Teachers' professional expertise cannot ignore anymore a technological component to it. Technology is nowadays accessible more and more widely, but it does not automatically translate into learning improvement. It is crucial to understand how educators give meaning to technology integration in their practices, i.e. investigate teachers' professional reasoning. The paper reports on part of a wider study on Initial Teacher Education (ITE) institutions' capability to engage student-teachers' reasoning. Within the broader multiple case study across Europe, the paper reports on data emerging from document analysis and focused interviews with pre-service teachers (N_{tot} 36). The findings suggest an activation of reasoning whose roots might find place outside ITE influence, encouraging further research.

Keywords: TPCK; Pedagogical Reasoning; Initial Teacher Education

Introduction

Technology figures as active agent in shaping educational practices, but notwithstanding the now wide access to these tools, that did not

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translate in the hoped learning improvements, as extensively reported in literature (e.g. OECD, 2015; Smits, Voogt & Van Velze, 2019). Understanding teachers' reasoning can be the key to analyse intended and in-place technology integration practices, as well as to foster their improvement. Moreover, initial teacher education is widely acknowledged as highly influential setting (Tondeur et al., 2016, 2017, 2019) to set the basis for sound reasoning processes even long term (Agyei & Voogt, 2011; Ertmer & Ottenbreit-Leftwich, 2010), as it is when teacher's professional expertise is first explicitly addressed and moulded. Several studies point at design tasks engaging student-teachers as powerful strategies to improve their professional expertise even with the use of technologies (Angeli & Valanides, 2009; Koehler & Mishra, 2005; Trevisan, 2020). Unfortunately, not many researches aim to uncover and scaffold the decisional processes underlying said design tasks, i.e. pedagogical reasoning.

The paper reports on a wider research on the capability of initial teacher education programmes to engage student-teachers' pedagogical reasoning (PR) when performing technology-integrated design tasks. In the form of a multiple case study across Europe it included multiple instruments for data collection, here reporting on focused interviews (N_{tot} 36), participant observation and document analysis. Preliminary findings suggest a peculiar activation of student-teachers' PR, which roots might derive from experiences outside from pre-service education programmes' influence. Given the pivotal role of initial education in shaping professional expertise, the present findings would suggest ITEs to re-consider their strategies' efficiency in fostering sound reasoning for technology integration.

Theoretical background

The Technological Pedagogical Content Knowledge TPCK (Mishra & Koehler, 2006) poses as framework to understand teachers' concurrent and interdependent understanding of content, general pedagogy, and technology, in consideration of the learning context (Angeli & Valanides, 2009). TPCK has been widely used in literature as language for discussing technology integration in instruction (Hammond & Manfra, 2009). Technology diffusion in educational practices is today ever more common, but still struggles to produce the hoped learning results (e.g. OECD, 2015).

While teachers' TPCK proficiency may be an effective enabler for technology integration, though, it alone cannot account for the different actual practices in place (Hall, 2010; Niederhauser & Lindstrom, 2018). Researchers suggest that technology integration practices lay strongly on teachers' self-confidence and pedagogical beliefs, as well as on how they perceive technological affordances (Kiran & Verbeek, 2010; Messina, Rossi, Tabone & Tonegato, 2015). These, in turn, are recognized and enacted in light of what teachers consider useful and aligned with their idea of teaching and learning. Technology integration is shaped by teachers' professional knowledge, which is both moulding and being predicted by tacit dispositions. It seems crucial to understand how teachers give meaning to technologies (e.g. the perceived pedagogical affordances – Angeli & Valanides, 2013; 2018; Webb & Cox, 2004) and which are teachers' motives and expectations shaped by their professional knowledge. Heitink and colleagues (2016), among others, remind us that the ways teachers cope with technology-enhanced educational practices ultimately depend specifically on how they professionally reason on the issue (see also Webb & Cox, 2004). Thus, pivotal is investigating teachers' PR for technology integration.

Although there is no unified theoretical model to understand this decisional process (Niederhauser & Lindstrom, 2018), the most accredited framework to this day goes back to 1987, with Shulman's *Model for Pedagogical Reasoning and Action* – MPR&A (Shulman, 1987; see also Loughran, Keast, & Cooper, 2016). He would mention several stages of such cognitive process which a skilful practitioner should be able to discuss (Shulman, 1987). In Shulman's words (1987), MPR&A figures as a dynamic and recursive process implying:

- Deep and critical *comprehension of subject matter*, as "to teach is first to understand" (Shulman, 1987, p. 14). Here, the teacher would reason about his/her own syntactic and synthetic knowledge of the discipline, balancing the general goals of education with context-related purposes of instruction.

- *Transformation* of the expert knowledge into *teachable content*, in forms that are both pedagogically powerful and adaptive to pupils' specificities. It involves other micro processes among which the selection of instructional strategies and the definition of goals tailored on the specific learners.
- *Instruction,* as the observable acts of teaching, classroom management, practices, and interactions with the pupils and the content.
- *Evaluation* of pupils' understanding and feedback strategies.
- *Reflection* as a review and analysis of the teacher's own performance. It entails the reconstruction of events and aims to personal/professional improvement through learning from experience.
- *New comprehension* of educational purposes, pupils, content and teaching practice.

Recently, Shulman's MPR&A has been either supported or criticized with the rising of revised models like Webb's (2002; Webb & Cox, 2004) also including knowledge, beliefs and values. Scholars like Harris and Phillips (2018) examined the very relevance of Shulman's model when it comes to technology-enhanced instruction, suggesting a shift in content (now comprising technologies not yet available in Shulman's times) but not much in the reasoning processes. Starkey (2010), on the other hand, modified MPR&A to specifically include digital technologies moving from the Connectivist perspective for learning (Siemens, 2005).

Whether to develop solid professional knowledge, positive dispositions or sound reasoning processes, initial teacher education is widely acknowledged as highly influential setting (Tondeur et al., 2016, 2017, 2019). Here, teacher's professional knowledge and skills are first explicitly addressed and dispositional barriers may be reduced, fostering a pedagogically sound reasoning resistant to external pressure.

Several researches have shown how acting on pre-service education can lead to long-term consequences for technology integration (see Agyei & Voogt, 2011; Ertmer & Ottenbreit-Leftwich, 2010; Tondeur et al., 2017), suggesting as one of the most effective practices the one of actively engaging student-teachers in design tasks. These would indeed provide opportunities to observe how technology, pedagogy, content and contextual factors (as for TPCK) mutually limit/reinforce each other (Baran & Uygun, 2016; De Rossi & Trevisan, 2018; Koehler & Mishra, 2005). Design tasks actively engaging student-teachers are found powerful in making them realize technologies' potentialities for learning (Angeli & Valanides, 2009; Koehler & Mishra, 2005; Trevisan, 2020). Furthermore, uncovering the decisional processes implied to perform such design tasks can enlighten on student-teachers' underpinning pedagogical/technological dispositions as well as their level of professional knowledge (Angeli & Valanides, 2009; Kramarski & Michalski, 2015). Nevertheless, there is not much research on how to offer TPCK-based design tasks explicitly supporting student-teachers' PR for technology integration, in pre-service education.

This paper reports on part of a wider research addressing the gap in literature about fostering PR in pre-service education, through hands-on experiences (i.e. design tasks). The research moves from the question: *How can student-teachers' pedagogical reasoning (PR) be engaged by TPCK-informed instructional design tasks?* Through this, it was sought to investigate if and how any reasoning dimension (Shulman, 1987; Starkey, 2010; see also Fig. 1 below) was triggered in student-teachers performing TPCK-based design tasks.

Methods

To answer the research question, a multiple case study research was set in place (Stake, 2006; Yin, 2003), with three case studies identified in the European context for ITE, namely in Cyprus (EU 1), Italy (EU 2) and The Netherlands (EU 3). The researcher observed student-teachers enrolled in university level courses dealing with technology integration in education (academic years 2017-18/2018-19). Participants were 17-22 years old, attending their first university course dealing with the topic. In those university courses, as an already in-place-routine, they were required to complete two cycles of technology-integrated instructional design.

Considering the theoretical background described above, the study moves within a TPCK perspective for teacher professional knowledge. Thus, TPCK-informed instructional design tasks were investigated as meaningful and interdependent infusion of technologies within content-based pedagogical practices (i.e. design tasks). Given the problematic theoretical agreement about what PR for technology integration may look like, in the present study the most widely accepted one was used as a basic reference: MPR&A by Shulman (1987). Furthermore, to account for any possible explicit digital technology-related declination of such reasoning process, Starkey's MPR&A-A[1] (2010) was also considered. The emerging adapted model is visible in Figure 1 and was used (a) to analyze documentary data (i.e. design tasks' guidelines), to identify in their content any keyword and/or theme relatable to PR dimensions and inner steps (top-down perspective); and (b) to analyse interview data to detect any possible PR manifestation.

Indeed, the research included several instruments for data collection, implementing a triangulation strategy for data analysis (Yin, 2003). Participant observation and document analysis, performed throughout 6 months in each context, provided information on the intended and perceived characteristics of the design tasks, related to the PR theoretical model (Shulman, 1987; Starkey, 2010; Trevisan, 2020). Focused interviews (Cohen, Manion & Morrison, 2007) were held at the end of each design cycle to investigate student-teachers' PR during TPCK-informed design tasks. Interviewees participated on a voluntary basis (N_{tot}= 36) to 30-45 min long interviews carried out in English, although a hard copy of the questions in the different native languages was also available. Interviews were semi-structured and focused, with questions addressing the different reasoning dimensions (according to Shulman, 2987; Starkey, 2010) and implementing the think aloud technique (van Someren, Bernard, & Sandberg, 1994) to verbalize PR during problem-solving tasks. Interviewees were guided to clarify their decisional steps in building a learning unit with open prompts like: "*What do you need to do to make yourself ready to enter classroom tomorrow? What do you need to think about?*". Whenever they would mention a decisional turning point[2], a "why" question was

1. Model for Pedagogical Reasoning and Action for the Digital Age (Starkey, 2010).

2. In relation to the PR dimensions mentioned (see Fig. 1 and Trevisan, 2020).

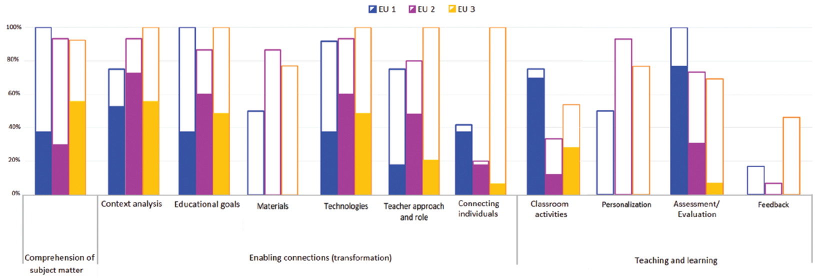

Figure 1. Traces od reasoning in TPCK-informed design task guidelines across cases (frequencies)

asked to go deeper into the interviewees' reasoning. Finally, some questions would address a possible connection between the interviewees' decisional process (PR) and the given design task guidelines, for example "*would you say your guidelines ask you to modify your topic to make it more accessible to your students* [i.e. transformation phase]*? How so?*".

Collected data was analysed through ATLAS.TI for content analysis, and this paper outlines the results answering the research question through documentation and interviews' evidence.

Results

The three TPCK-informed design task guidelines given to student-teachers in the single case studies were analysed to identify theoretical perspectives for technology integration, and foremost to investigate any reference to PR theoretical models like Shulman's (1987) or its digitally-modified version (Starkey, 2010). Each case study implemented the design tasks with specific guidelines and accompanying instructions:

- EU 1 made the guidelines mandatory in each and every aspect, referring to the transformative TPCK framework and *Technology Mapping* (TM) approach for technology integration (Angeli & Valanides 2009). TM aims at "making educational affordances of the tools explicit within the context of an authentic design task"

(Angeli & Valanides, 2013, p. 207) and it is enacted through specific design phases (i.e. the guidelines used).

- EU 2, while still making guidelines mandatory, set different focuses for the first and the second design cycle (namely, on teaching approaches, first, and on technological affordances, later). Among its many theoretical references there was Harris and Hofer's (2009, 2011) *Learning Activity Types* (LAT) and the integrative TPCK framework (Koehler & Mishra, 2005); and
- EU 3 used the guidelines as mere suggestions, letting student-teachers free to decide how to structure their design products. Among the many theoretical references there was *Meaningful Learning* (Howland, Jonassen, & Marra, 2012), and the *Substitution, Augmentation, Modification and Redefinition* model (SAMR – Puentedura, 2006).

Considering the keywords emerging from design tasks' guidelines (documentation) in relation to PR dimensions (Fig. 1; Shulman, 1987; Starkey, 2010), some matches and mismatches appeared (Table 1).

Documentary data helped understanding possible intended connections between the implemented design tasks and guidelines, and the PR theoretical perspective. Considering the commonalities in the three guidelines about possible matches to most PR dimensions, similar influences on the participants' elicited reasoning could be expected about e.g., *subject matter comprehension*, *enabling connections/transformation*, and partly about *teaching and learning* (i.e. classroom-based practices, and evaluation strategies). On the contrary, great differences in PR mentions linked to design tasks could have been foreseen with regards to decisions about *connections among learners*, *personalization*, and *reflection,* as the three guidelines differed in mentioning such issues.

While it might seem as the contextual guidelines ignored some reasoning dimensions (e.g. *personalization* and *feedback*), it is to highlight that these findings pertain only to the documentary guidelines given to the student-teachers to perform their design task. Additional input, also related to the "missing" reasoning dimensions, could have been prompted orally during classes, but these instances were considered less accountable data as attendance was not always 100%. Inter-

Table 1. PR dimensions explicitly mentioned in the contextual design guidelines

Pedagogical Reasoning dimensions (Shulman, 1987; Starkey, 2010; Trevisan, 2020)	EU 1	EU 2	EU 3
Comprehension of subject matter (core concepts and misrepresentations)	✓	✓	✓
Transformation of the subject matter in teachable content (enabling connections): Analysis of the contextual characteristics (adaptation)	✓	✓	✓
Identification of context-sensitive goals	✓	✓	✓
Selection of (technological) resources and teaching methods to engage previous knowledge	✓	✓	✓
Enable connections among groups and individuals to develop new knowledge			✓
Teaching and learning practices: Classroom-based acts, teaching approach	✓	✓	✓
Personalization strategies			
Assessment practices	✓	✓	✓
Feedback practices			
Reflection (critic review and analysis of teachers' decisions)			✓
New comprehension (of teaching, learning and context)			

estingly, the connection task guidelines-PR was not so straightforward.

Considering here only the data from the second interviews (N= 12 per case) so to minimize the possible effects of unfamiliarity with the task and its guidelines, a peculiar activation of PR dimensions was detected[3].

3. Interviews' data analysis followed a top-down and bottom-up logic: PR dimensions' codes were created considering the theoretical model (Fig.1), but emerging themes were also noticed, so to enrich the description of the phenomenon (Stake, 2006). For further details, see Trevisan (2020).

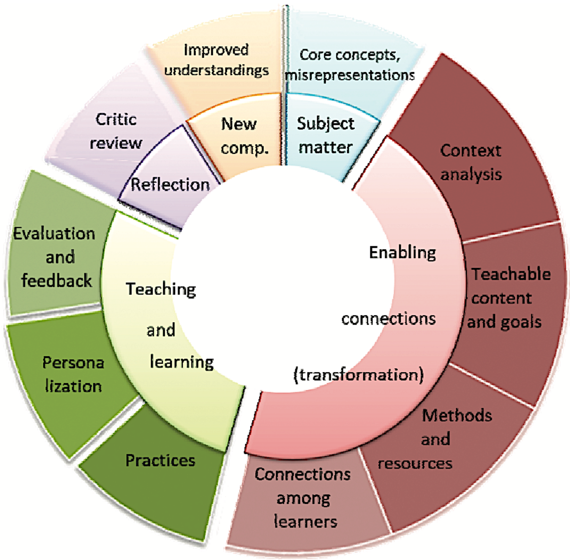

Figure 2. SEQ Picture /*ARABIC 1. PR adapted model in design task (Trevisan, 2020)

Figure 2 shows how many interviewees in each context would comment on a PR dimension (bars' outline), and how many would attribute their concerns on the issue to their task guidelines (bars' coloured areas), in frequencies ($N_{each\ case} = 12$).

While student-teachers report evidence of reasoning on most areas (bars' outlines), they struggled in relating those decisional processes to the requirements/use of the given guidelines (coloured areas). The three contexts seemed to share similar trends of high comments mainly in *comprehension of the subject matter*, and *transformation* (respectively $100\%_{EU1}$-$92\%_{EU3}$, and mostly above 50% in all three cases) dimensions, suggesting that pre-service teachers were really engaged in making clear decisions and preparing materials before entering the classroom. Interesting is the cross-case difference in mentioning *connecting individuals* reasoning, with EU3 strongly more active than the other two (100% versus $20\%_{EU2}$, $42\%_{EU1}$), as foreseeable from the given guidelines (see Table 1). As for the *teaching and* *learning* dimension, participants' PR was differently engaged according to the context, although the three cases seem to agree on the importance of reasoning about tailoring the learning experience on the pupils (*personalization* mentioned by 50%$_{EU1}$-93%$_{EU2}$) and *assessing* their improvements (69%$_{EU3}$-100%$_{EU1}$). Similarly joined, although in negative, are the three cases when considering reasoning about *feedback* (46%$_{EU3}$-7%$_{EU2}$).

Nevertheless, when looking at how many interviewees would clearly relate their reasoning steps to what they were required to do in their design tasks (coloured bars, Fig. 2), the findings are quite different. Rarely more than half of the interviewees in every context would deem their tasks guidelines relevant in trigger reasoning, except for the *contextual exploration* (58%$_{EU1}$ – 80%$_{EU2}$). Interesting is the identification of the uses of materials: *Technologies* gathered mentions between 42%$_{EU1}$ and 67%$_{EU2}$, with comments related to ICT affordances for improving comprehension and building new knowledge or enabling active and cooperative learning strategies. On the other hand, none of the interviewees would say that their tasks or guidelines induced them to think about the choice of non-technological *materials* (0%), a prompt that was instead found in the documentary material (see Table 1).

Moreover, as anticipated through documentation data, none of the task guidelines presented clear prompts for *personalization*, and that was indeed recognized by the interviewees, who would not find a match for their reasoning (0%). The decisional processes on this area, then, perceived detached from the tasks performed, must have different roots.

Finally, about *reflection* and *new comprehension*[4]. These were respectively mentioned only by 0%$_{EU1}$-38%$_{EU3}$ and 17%$_{EU1}$-60%$_{EU2}$ of the interviewees, although every one of them perceived the influence on these issues by the task guidelines.

Overall, the EU1 student-teachers were the ones more broadly recognizing relevance across the different PR dimensions, while EU3 participants were the ones least attributing relevance to their tasks in

4. Not in Figure 2 for readability reasons.

triggering reasoning. It is to say that these student-teachers openly admitted they did not use the given guidelines to perform the design task, preferring personal mental models or pre-made products.

Finally, the reader should bear in mind that the graph in Figure 2 accounts for frequencies of reasoning comments, not their pedagogical orientation or characteristics, which could give further insight on the PR occurring. Those characteristics are detailed in Trevisan (2020), where the wider research is fully addressed.

Conclusions

This paper reported on part of a wider research about student-teachers' PR for technology integration in technology-integrated design tasks. The research question investigated how TPCK-informed design guidelines, as offered in three ITE programmes, could engage student-teachers' PR (i.e. Fig. 1). The results here outlined would indicate that PR was indeed active during the implemented design tasks (Fig. 2), suggesting that Shulman's MPR&A still maintains relevance in student-teachers' PR even when considering digital technologies. Notwithstanding the inclusion of Starkey's (2010) model in the data analysis, no conclusive evidence was gathered on the presence of a paradigm specific for the technological era (e.g. connectivism) in shaping participants' PR (see also Harris & Phillips, 2018).

The reasoning mentioned does not seem highly linked to the guidelines implemented, regardless of their explicit mention of many dimensions (Table 1). Each of the single cases' design tasks and guidelines had their strengths in sparking some PR areas: EU1 for reasoning on classroom-based activities for knowledge building (*teaching and learning* dimension); EU2 for the definition of goals (*transformation*); and EU3 for a critic reflection about the profession (*reflection*). Moreover, all of them proved somewhat relevant in the eyes of the participants when it came to *context* sensitivity, and *ICT* affordances identification. This reminds of what suggested in academia (e.g. Angeli & Valanides, 2018): Through hands-on, technology-integrated experiences like design tasks, student-teachers develop deeper understanding of ICT value and affordances for specific educational contexts (Koehler & Mishra, 2005; Kramarski & Michalsky, 2015; Tondeur et al., 2019; Smart, 2016; Webb & Cox, 2004). Nonetheless, participants reported most of their reasoning instances detached from the given tasks and guidelines. Particularly weak seemed the connection about: Identifying *non-technological* resources and enacting flexible and *tailored* strategies in-action.

As widely reported in the literature, ITE has a great influence on teachers' technology integration practices even in the long run (Agyei & Voogt, 2011; Baran & Uygun, 2016; Ertmer & Ottenbreit-Leftwich, 2010; Farjon, Smits, & Voogt, 2019; Tondeur et al., 2016, 2017). Thus, it is essential to continuously revise ITE's offer in the attempt to equip student-teachers with the knowledge, attitudes, and abilities they will need to professionally reason for efficient acts of pedagogy (Loughran et al., 2016; Shulman, 1987). The findings emerging from the present research would suggest ITEs to give more serious attention to explicitly foster student-teachers' PR for technology integration, especially when engaging them in design tasks.

Finally, further insight might come from the analysis of the quality of reasoning, in terms of pedagogical orientation (e.g. teacher-/student-centred, see Trevisan, 2020). Possible implications of this research for educational policies in ITE programmes would suggest to re-consider their impact on student-teachers' professionalization, to better ensure the qualification of skilful practitioners (Shulman, 1987) with a sound reasoning and competence for technology integration.

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