

**Investigating the Pedagogical Content Knowledge of Teachers Attending a MOOC on Scratch Programming**

Rahimi, E.; Henze, I.; Hermans, F.; Barendsen, E.

2018, Article in monograph or in proceedings (Pozdniakov, S.N.; Dagien, V. (ed.), Informatics in Schools. Fundamentals of Computer Science and Software Engineering: 11th International Conference on Informatics in Schools: Situation, Evolution, and Perspectives, ISSEP 2018, St. Petersburg, Russia, October 10-12, 2018, pp. 180-193)

Doi link to publisher: [https://doi.org/10.1007/978-3-030-02750-6\\_14](https://doi.org/10.1007/978-3-030-02750-6_14)

Version of the following full text: Publisher's version

Published under the terms of article 25fa of the Dutch copyright act. Please follow this link for the Terms of Use: <https://repository.ubn.ru.nl/page/termsfuse>

Downloaded from: <https://hdl.handle.net/2066/197689>

Download date: 2025-06-11

**Note:**

To cite this publication please use the final published version (if applicable).



# Investigating the Pedagogical Content Knowledge of Teachers Attending a MOOC on Scratch Programming

Ebrahim Rahimi<sup>1,2</sup>(✉), Ineke Henze<sup>3</sup>, Felienne Hermans<sup>3</sup>,  
and Erik Barendsen<sup>1,2</sup>

<sup>1</sup> Radboud University, Nijmegen, The Netherlands  
{e.rahimi,e.barendsen}@cs.ru.nl

<sup>2</sup> Open University, Heerlen, The Netherlands

<sup>3</sup> Delft University of Technology, Delft, The Netherlands  
{f.a.henze-rietveld,f.f.j.hermans}@tudelft.nl

**Abstract.** The goal of this study is to investigate changes in PCK (Pedagogical Content Knowledge) of Dutch primary and secondary computer science teachers participating in a MOOC about Scratch programming. We captured the teachers' PCK using identical pre- and post-questionnaires and conducted a qualitative deductive-inductive content analysis to identify changes in the PCK of the MOOC attendees. We relate the observed differences between PCK before and after the MOOC to Clarke and Hollingsworth's model of teacher professional growth and Van Driel and Henze's model of PCK development. Our analysis gives rise to four design principles meant to inform the pedagogical design of such MOOCs and improve their pedagogical affordances with regard to PCK development of their attendees.

**Keywords:** Pedagogical content knowledge  
Computer science education · Secondary education · MOOC  
Scratch programming

## 1 Introduction

An “effective CS teacher” needs to have a knowledge base consisting of both content knowledge (CK) and pedagogical content knowledge (PCK) [4, 16]. PCK is needed by teachers to plan and deliver instruction and has been advocated as the unique sort of knowledge held by teachers that distinguishes them from experts and accounts more precisely for students' learning [11].

In an American context, it has been claimed that primary and secondary CS teachers generally have low PCK [22]. Solving this problem asks for proper professional development programs [22, 33]. The Internet serves as a promising professional development platform for teachers. Teachers' participation in online professional development can enhance their self-efficacy and provide the possibility to connect with people sharing similar pedagogical and content problems

[10,22]. It has been suggested that online and face-to-face professional development programs may have similar learning outcomes for teachers [22].

Massive open online courses (MOOCs) represent a fairly new web-based education initiative seeking to extend and offer educational services in an unprecedented scale [10]. MOOCs have been proposed as a “cost and resource effective means” for addressing the professional development needs of teachers [7, 10, 20]. To do so, such MOOCs must provide teachers with “the features, tools, resources, and interactions that will enable the acquisition of the various elements of good teaching” (outlined by Burns in [4]) including PCK [10] (p. 3). Thus, given the prominent role of PCK in teacher professional development, an important and open question about such MOOCs concerns with their influence on the PCK development of their attendees.

This study aims to investigate occurred changes in PCK of Dutch primary and secondary CS teachers attending a MOOC about Scratch programming. Notably, this MOOC was not initially devoted to supporting PCK development of attendees. Instead, it was meant to help them learn the content knowledge about Scratch programming. As such content-directed MOOCs are attended frequently by teachers with the purpose of supporting classroom practices, it is justifiable to investigate their influence on the teachers’ practical knowledge, in particular, their PCK.

One may question the idea of measuring PCK in the context of a course that is not meant for PCK development. Nevertheless, we support this idea for this MOOC based on two reasons: first, research has shown that there is a strong link between content knowledge (CK) and PCK in the context of mathematics and science education, so that teacher’s CK is necessary for developing PCK, but is not sufficient on its own [6]. This connection makes it appealing to investigate what happens with the CS teachers’ PCK when they participate in a content-focused course. Secondly, as the attendees are CS teachers, it is expected that they already have PCK of programming. Participation in this MOOC, as an external source according to [5,29], can contribute to changing their PCK of Scratch programming.

For the purposes of this study, two open-ended pre- and post-questionnaires, derived from the PCK model of Magnusson et al. [19] and a combination of CoRe instrument [18] and retrospective PCK-directed interviews [14], were administered among the MOOC attendees. Then, following a qualitative deductive-inductive research, the changes in the PCK of the attendees were identified. The results then were used to inform a set of pedagogical design guidelines for improving the effectiveness of such MOOCs concerning PCK development.

## 2 Background

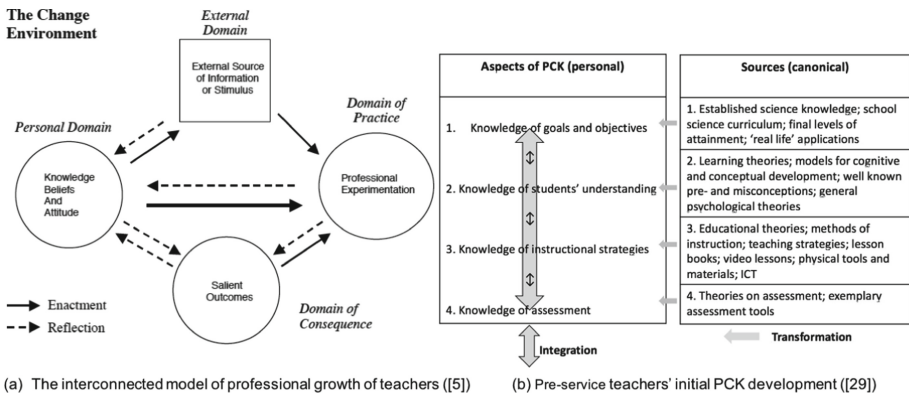
The PCK concept has been introduced by Shulman as the “missing paradigm” in the research on teacher knowledge and refers to “the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organized, represented, and adapted to the diverse interests and abilities

of learners, and presented for instruction” [27] (p. 8). Teachers’ PCK is their “pedagogical know-how” knowledge that develops during the years of teaching experience and describes the processes that teachers follow and employ in response to the challenges of teaching a given topic to particular students in specific settings [3, 27].

The most often cited model to describe teachers’ PCK has been proposed by Magnusson et al. [19]. This model defines five elements for teacher PCK on a specific topic, of which we use four (hereafter referred to as M1, M2, M3, M4, respectively): teacher knowledge about the objectives of teaching that topic (M1), teacher knowledge about the students’ understanding and learning difficulties with the topic (M2), teacher knowledge about effective instructional approaches to teach the topic (M3), and teacher knowledge about appropriate assessment strategies to assess the students’ understanding (M4) [19]. The Content Representation (CoRe) instrument, [18], captures the collective key ideas (of a group of teachers) connected to a specific topic, and elicits the teachers’ knowledge about each idea using 8 open questions. These questions cover the four elements of the PCK model of Magnusson et al. [19].

From a cognitive-constructivist perspective, the development of PCK goes through a non-linear, iterative and constructive process where new information is integrated with prior experiences, knowledge and beliefs captured from different domains, practices, and interactions. From a socio-cultural perspective, teacher PCK shapes and is developed through the transformation of subject-matter knowledge and communication process between teachers and students during classroom practices and interactions [13, 15], while from a situative perspective PCK is situated in the everyday practices of teachers and not only residing in individuals but also is distributed in their surrounding environment including books, tools, and their communities [15]. Collegial cooperation and knowledge, experience, and relationship exchanges among teachers have been proven to be essential for the development of teachers PCK [30]. Such exchanges might occur during face-to-face interactions happening within “conferences, department meetings, casual hallway conversations” or remote interactions emerging in various online platforms including social networking sites, MOOCs, blogs, and mailing lists [10, 12, 30].

Clarke and Hollingsworth’s empirical model for professional growth of teachers [5] and Van Driel and Henze’s theoretical model of PCK construction [29] (see Fig. 1) seem promising models to explain the professional growth and PCK development of teachers. Clarke and Hollingsworth’s model states that “external sources of information or stimulus” can make changes in the teacher’s “personal domain” by triggering her reflection on personal knowledge, beliefs, and attitude. Furthermore, these external sources might change the teacher’s “domain of practice” containing her professional experimentation by enacting new practices, for example, having experience with a new teaching strategy. According to Clarke and Hollingsworth’s model, the professional growth of teachers results from enactment and reflection mechanisms among external domain, personal domain, the domain of practice, and domain of consequence.



**Fig. 1.** Two models for explaining the PCK development process of teachers

As put by Van Driel and Henze, the development of PCK goes through two processes: a *knowledge transformation* process which (partly) draws upon external collective sources including learning theories, models for cognitive and conceptual development, well-known misconceptions, general psychological theories, methods of instruction, good practices, exemplary assessment tools, and so on, and a *knowledge connection and integration* process aiming at the internal coherence and relationship between the elements of PCK as a crucial factor to enable effective scaffolding of students' learning [21,29].

The PCK concept has been mainly investigated in connection with subjects such as physics, chemistry, and language [3,15]. CS teachers' PCK is a fairly new but promising research domain. As yet, there have been few attempts to elicit CS teachers' PCK [1,3,16,26,32]. While the majority of the research on investigating CS teachers' PCK has been conducted in connection with physical classrooms, we found only two studies examined the PCK development of CS teachers in online settings (i.e. [12,22]). In the first study, Go and Dorn investigated the PCK development of high school CS teachers participated in two online knowledge-sharing communities: one community provided the CS teachers with highly curated content devoted entirely to CS PCK, while another community was focused on unstructured content devoted to general CS education matters. The researchers discussed the strengths and weaknesses of both communities and speculated on how their benefits might inform an online community meant to facilitate CS teachers' PCK development [12]. Another research, conducted by Qian et al., presents the results of a 2-year study investigating how teachers teaching the CS principles course for the first time used online professional development (PD) materials. Their results show that novice teachers with a CS educational background needed and used PD materials for developing their PCK, while teachers with a Non-CS educational background needed and used PD materials for gaining content knowledge [22].

### 3 The Study Setting

As mentioned earlier, this study investigated the PCK change of a group of Dutch primary and secondary school teachers participated in a MOOC on Scratch programming. The primary aim of the MOOC in question was to help the attendees learn about Scratch programming (i.e. content knowledge) and become confident enough to implement it in their classrooms. The MOOC contained a set of videos, forums, questions, and course materials and was ran for 6 weeks starting from September 2017. Within the context of this MOOC, the study was directed by the following research question:

**RQ:** *How can the PCK and the changes in this PCK of the attendees of this MOOC be characterized?*

**Data Collection:** To answer the research question we constructed a questionnaire consisting of seven open-ended questions as presented in Table 1. The questions are based on the PCK model of Magnusson et al. [19] and a combination of the proposed questions by CoRe instrument [14, 18]. Two identical pre- and post-test online questionnaires as Table 1 were used as our data collection instruments in this study.

**Table 1.** The questions of pre- and post-test questionnaires

PCK elements ([19])	Questions about Scratch programming (adapted from [14, 18])
M1. Knowledge of goals and objectives	1. What do you intend students to learn about Scratch programming?
	2. Why is it important for the students to learn this?
M2. Knowledge of students' understanding and practices	3. What do you know about students' thinking (prior knowledge, learning difficulties) that influences your teaching of Scratch programming?
M3. Knowledge about instructional strategies	4. What do you think is a suitable method for teaching Scratch programming?
	5. What are your particular reasons for choosing this method?
M4. Knowledge about ways to assess students' understanding	6. What would be a suitable way of assessing students' understanding or confusion around Scratch programming?
	7. What are your reasons for choosing this particular way of assessment?

**Participants:** 375 people enrolled at the beginning of the MOOC. We selected the answers of those attendees who answered both pre- and post-test questionnaires (16 attendees) to do the analysis.

**Data Analysis:** A mixed deductive-inductive qualitative content analysis procedure [8] was followed. First, the answers in each phase were uploaded into Atlas.ti software collectively. Four elements (i.e. M1, M2, M3, M4) of Magnusson's PCK model [19] were used to group the answers in each phase. Within each group, the content of the PCK was analyzed inductively through identifying various codes, re-coding and merging into more general themes describing the variation among the teachers' PCK. Possible alternative interpretations of the identified codes were discussed within the research team until a consensus was reached.

## 4 Results

We present the results according to the PCK elements. Within each element, we describe the teachers' PCK organized by the themes emerging from the inductive analysis.

### Knowledge About Goals and Objectives (M1)

We discerned three categories of objectives for teaching Scratch programming expressed by the participants in the pre- and post-test questionnaires:

- i. *Knowledge-oriented objectives:* consisting of the following objectives: to learn about the structure of a program and its concepts, to understand how computers think and work, and to be prepared for actual programming languages.
- ii. *Motivational objectives:* consisting of these objectives: to make students interested in programming through making a game, to prepare them for a digital society, to motivate them by observing the influence of programming in their daily life, to provide them opportunity to experience more freely, and to make them prepared to work with Microbit.
- iii. *Personal development objectives:* consisting of the following objectives pertaining to improving soft and design competencies of students: enhancing logical reasoning via drawing plan and decomposing a problem, building trust and self-confidence in own abilities through discovering and expressing own ideas, and collaboration.

No significant difference between the patterns of appearing these objectives in the pre- and post-test questionnaires was identified.

### Knowledge About Students' Understanding and Performance (M2)

The following items present the participants' knowledge on students' understanding and performance in Scratch programming:

- i. *Students' general learning specifications:* reflected in statements such as *students can do more than what they show, students scare to try unknown*

*subjects, students have difficulty with independent working, students' lack of thinking ahead and solution-oriented approach, students with more ICT knowledge and experience resist to follow the instruction, and primary students have problem with Micro: Bit.*

- ii. *Students' reaction to Scratch*: including statements such as students find Scratch programming *childish, difficult, or interesting* and *students' knowledge about Scratch is more than me.*
- iii. *Students cognitive development stages*: representing general understanding and concerns about the level of cognitive capabilities of pupils for programming highlighted by some of the teachers in the post-test questionnaire.

These responses were observed with an almost identical pattern in the pre- and post-test questionnaires. The only remarkable difference was about the last item in the above list (i.e. *Students cognitive development stages*) which was only observed in the post-test answers.

### **Knowledge About Instructional Strategies (M3)**

The following items present the identified teachers' knowledge about instructional strategies associated with Scratch programming:

- i. *The generation strategy for programming*: referring teachers' knowledge about the *generation* approach to Scratch programming that emphasizes the generation of new programs by students from beginning. This type of knowledge was demonstrated in the pretest more than the post-test phase.
- ii. *The completion strategy for programming*: referring to teachers' knowledge about the *completion* approach to Scratch programming that emphasizes the modification and extension of existing programs by students. This type of knowledge was demonstrated in the post-test more than the pretest phase.
- iii. *First giving concrete examples then teaching abstract concepts*: denoting teachers' knowledge about a specific instructional strategy that asks teachers to first provide and explain concrete examples about a topic in Scratch programming (e.g. using video clips) and then use these examples to unpack the abstract concepts related to that topic. It is noteworthy that the appearance of this type of knowledge in the post-test was remarkably more than the pretest phase.
- iv. *First teaching abstract concepts then giving concrete examples*: implying teachers' knowledge about the traditional instructional strategy asking them to first explain the theory and abstract concepts about a topic in Scratch programming and then provide concrete examples to elaborate those concepts. This type of knowledge was observed in the pretest more than the post-test phase.
- v. *Fun-driven learning*: referring to the teachers' knowledge about the ways of making students' learning more playful via creating fun projects and connecting Scratch programming to students-favorited contexts such as Lego Mindstorms. Patterns of this type of knowledge were observed more in the post-test than the pretest phase.

- vi. *Unplugged activities*: denoting teachers' knowledge about unplugged activities and their benefits for teaching Scratch programming. We observed this type of knowledge mainly in the post-test phase.
- vii. *Group-based learning*: implying teachers' knowledge about the group-based learning strategies and their advantages. We saw no remarkable difference between the patterns of this type of knowledge in the pretest and post-test phases.

#### **Knowledge About Ways to Assess Students' Learning and Performance (M4)**

The following items describe teachers' knowledge about ways to assess students' understanding and performance in Scratch programming:

- i. *Generation-based assessment*: denoting teachers' knowledge about an assessment strategy that emphasizes the generation of a new program by students as a means for measuring their understanding and performance in Scratch programming. This type of knowledge was demonstrated in the pretest more than the post-test phase.
- ii. *Completion-based assessment*: denoting teachers' knowledge about an assessment strategy emphasizing the completion, debugging, explaining and predicting the results of an existing program by students as means for measuring their understanding and performance in Scratch programming. This type of knowledge was demonstrated in the post-test more than the pretest phase.
- iii. *Unstructured, observation-based assessment*: referring to teachers' knowledge about an open and observation-based assessment strategy that emphasizes allowing students' group working with Scratch and listening to their conversations to capture their possible understanding and misconceptions of Scratch topics. This type of knowledge was mainly observed in the pretest phase.

## **5 Discussion**

The discerned teachers' knowledge about the objectives of Scratch programming (M1 element of PCK) in both pre-test and post-test phases depicts a continuum ranging from more theoretical and knowledge-oriented objectives to more practical objectives with no significant difference in pre- and posttest phases. These findings concur with the results reported by [1, 23] pertaining CS teachers' knowledge about the objectives of programming.

The captured teachers' knowledge on students' understanding and performance in Scratch programming is limited to general learning specifications of students including knowledge about students general learning problems, their reactions to Scratch and their cognitive development stages. The latter item was only observed in the post-test phase which likely resulted from the explicit emphasis of the MOOC instructor on neo-Piagetian perspectives of cognitive

development of novice programmers (see [17]). No specific knowledge about students’ needs, motivations, misunderstanding and problems with Scratch was observed. Teachers’ insufficient understanding of their students decreases their teaching quality [19,24]. As put by Berglund and Lister, “we know very little about our students’ world and our students’ motivations... We tend to base our teaching on our own needs, or our assumptions about the students’ needs.” [2] (p. 42).

Figure 2 presents the participants’ evaluation of the MOOC elements. As shown, the forums were perceived as least useful element of the MOOC.

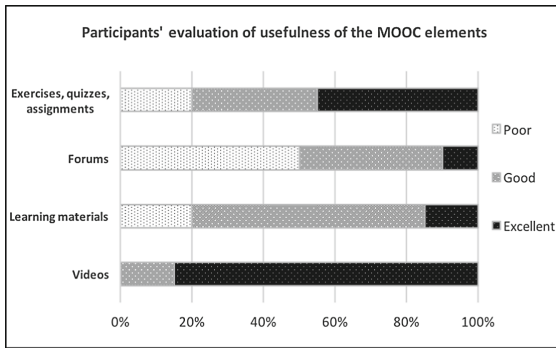


Fig. 2. The evaluation of the participants about the usefulness of the MOOC elements

There are two interesting observations related to the development of the participants’ knowledge about instructional strategies (M3): a shift from the *generation to completion* instruction for programming (for more information about these instructional strategies see [31]) and, a shift from *First teaching abstract concepts then giving concrete examples* to *First giving concrete examples then teaching abstract concepts* strategy. Arguably, these developments can be attributed to the participants’ exposure to the MOOC and its underpinning instructional strategy focused on the completion strategy as well as explaining concrete examples before teaching abstract concepts.

Clarke and Hollingsworth’s model of teacher professional growth [5] along with Van Driel and Henze’s model of PCK construction [29] (depicted in Fig. 1) can be used to explain the mentioned PCK developments. Through the lens of these models the external sources including the participants’ exposure to the MOOC and its promoted instructional strategies as well as provided videos and content appeared to have served to initiate a *knowledge transformation* process or trigger the participants’ reflection on their *personal domain* of knowledge, beliefs, and attitudes. The following quote by one of the participants is one of the few examples explaining the ways that some of the discussed concepts in the MOOC such as the Neo-Piagetian perspective of programming served to trigger the teacher’s reflection on her personal knowledge domain (the *knowledge*

transformation process) and connect and integrate her PCK elements (M2 and M3) (the *knowledge connection and integration* process):

*I found the discussion about the Neo-Piagetian perspective of programming very interesting. There are teachers with high knowledge and experience in Scratch. If they want to teach pupils to program in Scratch, their teaching might be inappropriate to improve the thinking of a pupil who needs to learn something totally new [M2] ... I think recognizing the difference between teachers' and pupils' cognitive level [M2] is very important to teach programming and this difference asks for a step by step instructional approach [M3].*

As suggested by the results, the observed changes in the participants' knowledge of instructional strategy seem to be influential in the changes happened to teachers' knowledge about assessment (M4 elements). This observation suggests a *knowledge connection and integration* process between M2 and M3 elements of teachers' PCK.

Although the presented analysis is based on the collective demonstration of the participants' PCK in the pre- and post-test phases, the outcomes can be traced back to the individual level. Table 2 in appendix A presents the developments in the demonstrated instructional knowledge of the participants. The developments of the instructional knowledge explained earlier can be seen at the individual level for several participants including teachers 2, 4, 14, 16.

Informed by the above findings and discussions, we formulated the following design principles to improve the pedagogical affordances of such MOOCs for enhancing CS teachers' PCK.

**Explaining Well-Known Students' Misconceptions Related to a Specific Topic:** The results indicated low developments in the participants' knowledge about students' understanding and performance in Scratch. Teachers' knowledge of students' understanding of a specific topic forms the core part of their PCK on that topic. According to [29], teachers' knowledge of strategies to teach a certain topic is related to their knowledge of how students learn that topic including their misconceptions [29] (p. 1). Thus, explaining the common misconceptions students experience in learning a topic and exploring their reasons and solutions can contribute to enhancing teachers' PCK on that topic.

**Encouraging and Facilitating Social Interactions Around the Content:** As depicted by Fig. 2, the quality of social aspects and interactions between the attendees in this MOOC was low. PCK is to some extent a collective and sharable knowledge [30]. Collegial cooperation and exchanging knowledge, experience (e.g. over students' misconceptions and difficulties), values and relationships among teachers is essential for the development of their PCK [30]. As asserted by [9], stimulated reflection, attending PCK courses, and contact with other teachers are typically part of effective interventions to promote PCK development in initial teacher education. CS teachers, in particular, may suffer more from this undermined social interaction given that they are most often the only people in their schools teaching CS subjects and may lack formal training in CS content [12, 33].

**Recognizing the Diversity of CS Teachers' Background and Experience:** Diversity in the knowledge, background, and expertise of attendees is common in MOOCs [25]. As shown by [22], the teaching experience and computing background of CS teachers have a significant impact on their need for and use of online professional development materials including MOOC-based education. It has been observed that novice CS teachers needed and used online professional development materials for developing their PCK, while Non-CS teachers needed and used these materials to gain content knowledge. Addressing this diversity asks for matching professional development to teachers' background [22].

**Facilitating the Interaction Between the PCK Gained from MOOCs and Teachers' Educational Practices:** As shown, the participants' exposure to this MOOC appeared to have served to enhance their knowledge about instructional and assessment strategies. From the perspective of Clark and Hollingsworth's model [5] to promote professional growth of teachers this knowledge should inform their "domain of practice" through professional experimentation. On the other hand, through the lens of Van Driel and Henze's model of PCK construction [29], teachers' experimentation in their "domain of practice" can connect and strengthen their PCK elements through *knowledge integration* and *knowledge transformation* processes. Along similar lines, Van Driel [28] emphasized the importance of providing opportunities for teachers to experiment in their own practice as a key factor to develop their knowledge including their PCK. Explicating the pedagogical premises and strategies underpinning such MOOCs seems useful to ease transferring the gained PCK by participants to their domain of practice and facilitate the interaction between building PCK and experimenting in practice.

## 6 Conclusions

This paper investigates changes in the PCK of the attendees at a Scratch MOOC. Some remarkable PCK changes were observed mainly in the attendees' knowledge about instructional strategies and assessment. These changes likely stem from the attendees' exposure to the instructional strategies followed in this MOOC. Four design principles were formulated to inform the pedagogical design of such MOOCs and improve their effectiveness with respect to the PCK development of their attendees. The formulated design principles emphasize explaining well-known students' misconceptions about MOOC topics, facilitating social interactions within the MOOC, recognizing and capitalizing the diversity in background and experience of MOOC attendees, and encouraging attendees to apply their gained PCK in practice. The method and questionnaires used for capturing participants' PCK seem promising for supporting other studies about the PCK development in MOOCs. We propose a follow-up study to embed the suggested design principles in a similar MOOC and investigate the changes in the PCK of its attendees.

## Appendix A

**Table 2.** The demonstrated instructional knowledge of the participants in the pre- and posttest phases

Teacher	Pretest	Posttest
1	-	First giving concrete examples then teaching abstract concepts
2	First teaching abstract concepts then giving concrete examples	First giving concrete examples then teaching abstract concepts education, Differentiated learning, Completion-based instruction
3	First teaching abstract concepts then giving concrete examples, the generation strategy	-
4	First teaching abstract concepts then giving concrete examples, the generation strategy	First giving concrete examples then teaching abstract concepts, group working, the completion strategy, unplugged activities, fun-driven learning
5	-	-
6	Fun-driven learning, First teaching abstract concepts then giving concrete examples	Group working
7	Group working	-
8	-	First giving concrete examples then teaching abstract concepts, the completion strategy
9	Conducting short assignments	First giving concrete examples then teaching abstract concepts, the completion strategy, fun-driven learning
10	Differentiated learning, First teaching abstract concepts then giving concrete examples	-
11	Accomplishing focused assignments	First teaching abstract concepts then giving concrete examples, Fun-driven learning
12	Fun-driven learning, group working, the generation strategy, contextualized learning, video-based teaching	-
13	the generation strategy, first teaching abstract concepts then giving concrete examples, fun-driven learning	-
14	The generation strategy, first teaching abstract concepts then giving concrete examples	First giving concrete examples then teaching abstract concepts, the completion strategy
15	The completion strategy	Group working
16	First teaching abstract concepts then giving concrete examples	Fun-driven learning, differentiated learning, group working

## References

1. Barendsen, E., Dagienė, V., Saeli, M., Schulte, C.: Eliciting computer science teachers' PCK using the Content Representation format: experiences and future directions. In: Gülbahar, Y., Karataş, E., Adnan, M. (eds.) *Proceedings of the 7th International Conference on Informatics in Schools: Situation, Evolution and Perspectives (ISSEP 2014), Selected Papers*, pp. 71–82 (2014)
2. Berglund, A., Lister, R.: Introductory programming and the didactic triangle. In: *Proceedings of the Twelfth Australasian Conference on Computing Education*, vol. 103, pp. 35–44. Australian Computer Society, Inc. (2010)
3. Buchholz, M., Saeli, M., Schulte, C.: PCK and reflection in computer science teacher education. In: *Proceedings of the 8th Workshop in Primary and Secondary Computing Education*, pp. 8–16. ACM (2013)
4. Burns, M.: *Distance Education for Teacher Training: Modes, Models and Methods*. Education Development Center Inc., Washington (2011)
5. Clarke, D., Hollingsworth, H.: Elaborating a model of teacher professional growth. *Teach. Teach. Educ.* **18**(8), 947–967 (2002)
6. Daehler, K.R., Heller, J.I., Wong, N.: Supporting growth of pedagogical content knowledge in science. In: *Re-examining Pedagogical Content Knowledge in Science Education*, pp. 55–69. Routledge (2015)
7. Dikke, D., Faltin, N.: Go-Lab MOOC-an online course for teacher professional development in the field of inquiry-based science education. In: *7th International Conference on Education and New Learning Technologies (2015)*
8. Elo, S., Kyngäs, H.: The qualitative content analysis process. *J. Adv. Nurs.* **62**(1), 107–115 (2008)
9. Evens, M., Elen, J., Depaepe, F.: *Developing Pedagogical Content Knowledge: Lessons Learned from Intervention Studies*. Education Research International 2015 (2015)
10. Fyle, C.O.: Teacher education MOOCs for developing world contexts: issues and design considerations. In: *Proceedings of the Sixth Conference of MIT's Learning International Networks Consortium (LINC)* (2013)
11. Gess-Newsome, J.: A model of teacher professional knowledge and skill including PCK. In: Berry, A., Friedrichsen, P., Loughran, J. (eds.) *Re-examining Pedagogical Content Knowledge in Science Education*, pp. 28–42. Routledge (2015)
12. Go, S., Dorn, B.: Thanks for sharing: CS pedagogical content knowledge sharing in online environments. In: *Proceedings of the 11th Workshop in Primary and Secondary Computing Education*, pp. 27–36. ACM (2016)
13. Greeno, J.G., Collins, A.M., Resnick, L.B.: Cognition and learning. In: Berliner, D.C., Calfee, R.C. (eds.) *Handbook of Educational Psychology*, pp. 15–46. Macmillan, New York (1996)
14. Grossman, P.L.: *The Making of a Teacher: Teacher Knowledge and Teacher Education*. Teachers College Press, New York (1990)
15. Henze, I., Van Driel, J.H.: Toward a more comprehensive way to capture PCK in its complexity. In: Berry, A., Friedrichsen, P., Loughran, J. (eds.) *Re-examining Pedagogical Content Knowledge in Science Education*, pp. 120–134. Routledge (2015)
16. Hubwieser, P., Magenheimer, J., Mühling, A., Ruf, A.: Towards a conceptualization of pedagogical content knowledge for computer science. In: *Proceedings of the Ninth Annual International ACM Conference on International Computing Education Research*, pp. 1–8. ACM (2013)

17. Lister, R.: Concrete and other neo-piagetian forms of reasoning in the novice programmer. In: Proceedings of the Thirteenth Australasian Computing Education Conference, vol. 114, pp. 9–18. Australian Computer Society, Inc. (2011)
18. Loughran, J., Mulhall, P., Berry, A.: In search of pedagogical content knowledge in science: developing ways of articulating and documenting professional practice. *J. Res. Sci. Teach.* **41**(4), 370–391 (2004)
19. Magnusson, S., Krajcik, J., Borko, H.: Nature, sources, and development of pedagogical content knowledge for science teaching. In: Gess-Newsome, J., Lederman, N.G. (eds.) *Examining Pedagogical Content Knowledge*, pp. 95–132. Kluwer, Dordrecht (1999)
20. Misra, P.K.: MOOCs for teacher professional development: reflections and suggested actions. *Open Praxis* **10**(1), 67–77 (2018)
21. Park, S., Chen, Y.C.: Mapping out the integration of the components of pedagogical content knowledge (PCK): examples from high school biology classrooms. *J. Res. Sci. Teach.* **49**(7), 922–941 (2012)
22. Qian, Y., Hambrusch, S., Yadav, A., Gretter, S.: Who needs what: recommendations for designing effective online professional development for computer science teachers. *J. Res. Sci. Teach.*, 1–18 (2018)
23. Rahimi, E., Barendsen, E., Henze, I.: Typifying Informatics teachers' PCK of designing digital artefacts in dutch upper secondary education. In: Brodnik, A., Tort, F. (eds.) *ISSEP 2016. LNCS*, vol. 9973, pp. 65–77. Springer, Cham (2016). [https://doi.org/10.1007/978-3-319-46747-4\\_6](https://doi.org/10.1007/978-3-319-46747-4_6)
24. Rahimi, E., Barendsen, E., Henze, I.: Identifying students' misconceptions on basic algorithmic concepts through flowchart analysis. In: Dagiene, V., Hellas, A. (eds.) *ISSEP 2017. LNCS*, vol. 10696, pp. 155–168. Springer, Cham (2017). [https://doi.org/10.1007/978-3-319-71483-7\\_13](https://doi.org/10.1007/978-3-319-71483-7_13)
25. Ross, J., Sinclair, C., Knox, J., Macleod, H.: Teacher experiences and academic identity: the missing components of MOOC pedagogy. *J. Online Learn. Teach.* **10**(1), 57 (2014)
26. Saeli, M.: *Teaching Programming for Secondary School: a Pedagogical Content Knowledge Based Approach*. Ph.D. thesis, Eindhoven University of Technology, The Netherlands (2012)
27. Shulman, L.: Knowledge and teaching: foundations of the new reform. *Harv. Educ. Rev.* **57**(1), 1–23 (1987)
28. Van Driel, J.: Model-based development of science teachers' pedagogical content knowledge. In: *International Seminar, Professional Reflections, National Science Learning Centre, York* (2010)
29. Van Driel, J.H., Henze, I.: Extended paper for PCK summit, Colorado (2012). <http://pcksummit.bsccs.org>
30. Van Driel, J.H., Verloop, N., de Vos, W.: Developing science teachers' pedagogical content knowledge. *J. Res. Sci. Teach.* **35**(6), 673–695 (1998)
31. Van Merriënboer, J.J.: Strategies for programming instruction in high school: program completion vs. program generation. *J. Educ. Comput. Res.* **6**(3), 265–285 (1990)
32. Yadav, A., Berges, M., Sands, P., Good, J.: Measuring computer science pedagogical content knowledge: An exploratory analysis of teaching vignettes to measure teacher knowledge. In: *Proceedings of the 11th Workshop in Primary and Secondary Computing Education*, pp. 92–95. ACM (2016)
33. Yadav, A., Gretter, S., Hambrusch, S.: Challenges of a computer science classroom: initial perspectives from teachers. In: *Proceedings of the Workshop in Primary and Secondary Computing Education*, pp. 136–137. ACM (2015)