

Pre-service teachers' interpretation of technology-rich teaching and learning episodes

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This paper concerns a pre-service teachers' professional development (PD) program focusing on the use of technology in which participants: experienced collaborative task design of a teaching sequence; reflected on the implementation of the designed sequence; and performed detailed video analysis of a lesson in which the sequence they have designed was enacted by an expert teacher. We illustrate the case of a video analysis developed by one of the participants using the Semiotic Bundle lens and the Timeline tool. Results are presented and discussed with the aim of showing how the approach of this PD program can foster pre-service teachers' ability to interpret technology-rich teaching and learning episodes.

Keywords: Collaborative task design, Video analysis, Technology-rich teaching and learning episodes, Semiotic Bundle, Pre-service teachers' professional development.

Introduction

Many research studies are devoted to designing and evaluating teachers' education in mathematics and professional development (PD) programs focusing on the use of digital resources. In particular, teachers' design of teaching activities has been acknowledged to improve teaching practices (i.e. Zaslavsky, 2008). Moreover, videos have been recognised as effective tools for teachers' professional development: Sherin and Han (2004), for instance, underlined that video allows teachers to slow down instructional interactions and closely examine what happened. Gaudin and Chaliès (2015) identified two common objectives for the use of video as a tool for teacher learning: (1) building knowledge of how to interpret and reflect on episodes of teaching and learning; and (2) building knowledge of what to do. However, to the best of our knowledge, the joint experience of task design and video analysis in pre-service teachers' PD programs, particularly those aiming to integrate digital resources in mathematics education, has not yet been investigated enough. With this paper we attempt to contribute to this field. Offering and discussing the results of an ongoing study, we focus on pre-service teachers' interpretation of class activities involving digital resources. In particular, we are interested in how pre-service teachers interpret a teaching and learning episode and how the ability to perform this interpretation is affected by their involvement in task design and video analysis. To do this we illustrate and discuss the case of a pre-service teacher who participated in a PD program based on the joint experience of collaborative task design and individual video analysis. Her video analysis shows the effect of the PD program on her interpretation and reflection on a technology-rich teaching and learning episode.

Theoretical framework

In this section, we briefly present the theoretical point of view which framed this study. According to Clarke and Hollingsworth (2002) we believe that facilitating the professional development of teachers requires the recognition of the complexity of the process. The Clarke and Hollingsworth's

Interconnected Model suggests that teachers' professional learning occurs through the mediating processes of "reflection" and "enactment", in four distinct domains which encompass the teacher's world: the Personal Domain (teacher knowledge, beliefs and attitudes), the Domain of Practice (classroom experimentation), the Domain of Consequence (salient outcomes), and the External Domain (sources of information, stimulus or support). Hence, in accordance with this model, in our PD program we intended to offer pre-service teachers opportunities to facilitate their "reflection" (in Dewey's (1910) sense of "active, persistent and careful consideration") and inform their future professional "enactment" (to be seen as "the translation of a belief or a pedagogical model into action"). The main hypothesis of our work is that the joint experience of collaborative task design and video analysis can contribute to the pre-service teachers' professional growth. More precisely, we assume that the former represents the mean used to foster changes in their knowledge and beliefs informing future enactment. Whereas, the latter –in which they observe and interpret an expert teacher's behaviour while putting into action the outcomes of the former– constitutes the basis for their reflection.

Research questions

Analysing the case presented in this paper, we intend to study how the approach of the PD program –described in detail below– can foster pre-service teachers' ability to interpret technology-rich teaching and learning episodes. With respect to our hypothesis, the interpretation of an episode represents the way the reflection is exhibited. Thus, the research questions we aim to answer are: a) how does the pre-service teacher interpret the technology-rich teaching and learning episode? b) what are the effects of the joint experience of collaborative task design and individual video analysis on her ability to perform this interpretation?

Methods

Twelve pre-service mathematics teachers participated in a PD program articulated in the following phases: a) they were asked to accomplish, in small groups, a sequence of tasks involving the use of digital and non-digital resources and they discussed their experience (Mennuni & Faggiano, 2020); b) they were introduced to the theoretical perspective which framed the sequence that they were exposed to and they were asked to use it to collaboratively task design a similar sequence for middle school students (Mennuni et al., 2021); c) they experimented the designed sequence in an online 7th-grade class and collectively analysed its results using the theoretical framework they have used in the task design; d) they observed an expert teacher conducting the final revised version of the same sequence, in presence, in her 7th-grade class and they performed individual detailed video analysis of some teaching and learning episodes of this class activity.

The teacher who gave her availability to experiment with the sequence of tasks in her class has more than 15 years of teaching experience. She has a master's degree in mathematics and participated in many in-service professional development initiatives. She acted as a mentor teacher to pre-service and in-service teachers and coordinated many projects to foster STEM education in her school. For these reasons, she can be considered an expert teacher (Li & Kaiser, 2011). She was provided with a description of the tasks, as well as their aims, that compose the sequence as it was designed by the pre-service teachers during the collaborative phase of the program.

Each participant was invited to analyse some episodes, chosen according to the important aspects that emerged during the previous phases of the program, and to write a final report presenting and commenting on their video analysis. All the activities of the PD program have been video-recorded and the pre-service teachers' individual written reports have been collected. Due to the limits of space, in this paper, we refer only to the video analysis of one of the pre-service teachers (ST1), presenting the video analysis of the episode she considered most important. The results are discussed with the aim to identify elements revealing her reflections. In particular, we are interested in bringing to the fore how, with her video analysis, ST1 interpreted the teaching and learning episode and how her ability in the interpretation was affected by the previous activities experienced during the PD program.

The example of individual video analysis

In this section, we introduce the example of video analysis performed by ST1. The description of the example, that will be given in the results section, requires two preliminary brief insights. The first one concerns the description of the task at stake in the selected analysed part of the video. The second regards the theoretical point of view which framed the ST1's analysis, namely the Semiotic Bundle lens (Arzarello, 2008), based on the model of the space of Action, Production, and Communication (APC-space).

The description of the analysed task

The sequence of tasks, on which the PD program was focused, concerns the notion of rotation and is based on the synergic use of digital and non-digital resources (Faggiano & Mennuni, 2020). The part of the video that is analysed in the example refers to a collective discussion, orchestrated by the expert teacher, after the task in which students were asked to identify the centre of the rotation between two figures. Students have worked individually interacting with a GeoGebra file that displays two flags, one of which is the rotated version of the other: they were asked to identify the centre of the rotation that allows one flag to be transformed into the other. This is the most significant part of the entire teaching sequence on rotation, as it requires students to use the considerations and properties that have emerged in the previous parts. Indeed, to identify the centre, students need to use the already discovered property of rotated figures: each pair of corresponding points has the same distance from the centre of rotation. This means that the centre belongs to the perpendicular bisector of every segment joining each pair of corresponding points. Thus, to find the centre of the rotation it is necessary (and sufficient) to intersect any two of these perpendicular bisectors. The aim of the final discussion, hence, is to let students explain how they have found the centre, so that the discovered properties can give meaning to the rotation.

The Semiotic Bundle lens

The APC space has been introduced by Arzarello and colleagues (2009) as a model that intends to frame the processes that develop in the classroom among students and the teacher while working together. When students interact with each other and with the teacher during a specific classroom activity, the results are not a linear development, but a complex interplay of interactions composed of multimodal actions, productions, and communications. Consequently, as the variables present within the classroom are multiple and intertwined, teaching-learning processes become a complex

system whose analysis requires a multimodal perspective. However, the main components of the APC space –the body, the physical world, and the cultural environment– need to include students’ perceptual-motor experiences, their languages, the produced signs, and all the resources they use to interact with each other, the tools and the teacher. In these complex processes, the role of the teacher also turns out to be crucial. Her responsibility is to design and implement teaching activities appropriately and to foster the evolution of the students’ personal signs towards shared mathematical signs through her interventions. Arzarello chooses the semiotic lens to investigate the APC space, which he frames in the notion of Semiotic Bundle (SB). The latter is defined as a complex system, evolving over time, of signs that are produced by a student or a group of students to tackle an appropriate teaching sequence, while interacting with each other, with the teacher and with the resources. For a more in-depth analysis of all the interactions, video recordings play a crucial role because they can be examined in detail in order to analyse the observed processes carefully. Based on these videos, a transcript, including information about gestures, is produced and used to build the Timeline (TL). The TL is a table that offers an overview of the a posteriori micro-analysis of the elements that characterise the different registers of the SB: spoken (complete transcripts of the interactions between students and with the teacher); embodied (i.e., the gestures that represent the conversation and that are classified in McNeill’s (1992) four dimensions); written (the representations produced by the teacher and students).

Results







Time	00:08:00	00:08:03	00:08:03	00:08:03	00:08:06	00:08:20	00:08:48	00:09:00	00:09:15	00:12:27	00:12:42	00:12:50
	Teacher	Maria	Ilaria	Teacher	Ilaria	Teacher	Ilaria	Teacher	Ilaria	Teacher	Ilaria	Ilaria
Utterances	Teacher	Ilaria, what did you draw?		Why?		We said that the perpendicular bisector has two properties. What are they?		Each point on this perpendicular bisector has the same distance from the extremes. So, what can you say, Ilaria?		What did you do, Ilaria?		
	Students		The perpendicular bisector of the segment		Because that is the point that joins A with A', being the midpoint, maybe that is where the other midpoints of the other segments will be found		Every point on the perpendicular bisector is equidistant from the segment		So that if we find the other midpoints of BB', CC', DD' on that perpendicular bisector.	I drew the perpendicular bisector of the segment CC' too.		Maybe we can also test with the other segments and see if the midpoint is the one.
Gestures	Students		 iconic		 metaphoric		 metaphoric					
	Teacher							 metaphoric				
Interaction with artefact	Teacher											
	Students											

Figure 1: A part of the ST1’s TL

To analyse the way in which ST1 interprets the episode, we illustrate here, with ST1’s words, a part of the timeline she built (Figure 1) and the related comments that she wrote in her final report. Results refer to the episode in which students realise how to determine the centre of rotation. According to ST1’s added comments, the TL represents “the semiotic analysis of the crucial passage in the video”.

Moreover, to discuss ST1's interpretation it is worth noting that, with respect to the description of this task, in the introduction of her final report ST1 highlights that:

In this activity, the teacher's role is crucial in emphasising that the point is not to be positioned randomly but must be found by exploiting the properties that have emerged so far. If the teacher realises that none of her students can initiate a correct procedure, she could suggest considering the segments connecting the corresponding points and working on them.

The analysed episode lasts about 5 minutes and was described and commented by ST1 using the Timeline, partially shown in Figure 1. Below we present the comments she wrote to describe the TL.

0:08:00 - 0:08:03 - Ilaria had shared her screen with the class, and while looking for the centre of rotation she inserted an element, the perpendicular bisector of the segment, which was immediately observed by the teacher. Knowing that this was the correct procedure, she invited Ilaria to explain what she was doing and asked her what she had drawn. Ilaria soon answered: "the perpendicular bisector of the segment". At the same time, Maria iconically drew in the air, using the pen, first a vertical line from top to bottom and then a second line perpendicular to the first, marking the right angle that was formed. She also identified the perpendicular bisector.

It is worth noting that, although the teacher didn't react to Maria's gesture, ST1 decides to report it in the TL.

0:08:05 - 0:08:06 - The teacher asked Ilaria to clarify why she drew the perpendicular bisector of the segment. And once again she immediately answered: "Because that is the point that joins A with A' [n.a. the corresponding, rotated, point of A], being the midpoint, perhaps the other midpoints of the other segments will be found there". Ilaria realised that the midpoint of segment AA' alone cannot be the centre of rotation, because it is only equidistant from A and A'. Hence, she realised that it is necessary to also consider other segments, whose extremes are corresponding points. In fact, Ilaria's answer is accompanied by a metaphorical gesture, with which, moving her index finger from left to right repeatedly, she pointed to the segments connecting their respective extremes.

In what follows, the video shows Ilaria interacting with GeoGebra but her actions were not considered important by the teacher, and also by ST1. Indeed, ST1's TL and comments continue as follows:

0:08:20 - 0:08:48 - The teacher perceived that Ilaria possesses the notion of the perpendicular bisector. However, she asked Ilaria to remind her classmates what are the properties of this geometric concept. In this way, the teacher involved the entire class in the construction of the centre, making each pupil aware of the intermediate steps they are taking. Ilaria answered: "any point on the perpendicular bisector is equidistant from the segment". She further specified the mentioned property with a metaphorical gesture: Ilaria joined her hands as if they were on a point on the perpendicular bisector, and then moved them contemporaneously from the point of joining, emphasising the equidistance of each point on the perpendicular bisector from the extremes of the segment under consideration.

The TL part concerning the following seconds of the episode shows the teacher's reaction to Ilaria's reasoning. ST1's comments reveal the teacher's choice to let students follow Ilaria's reasoning and develop their own strategies to find the centre.

0:09:00 - 0:09:15 - The teacher obviously approved what Ilaria had said and repeated to the whole class the property interacting with GeoGebra. She initially pointed with the two index fingers to a random point on the perpendicular bisector of segment AA' and then simultaneously moved the index finger to A' and the left index finger to A. At this point, she asked Ilaria to continue with her reasoning. And Ilaria replied: "...if we find the other midpoints of BB', CC', DD' on that perpendicular bisector..." So, she has realised that the midpoint of a single segment is not enough. One more step, one more concept, is needed than that of the perpendicular bisector. Ilaria knows that all points on the perpendicular bisector of the segment have the same distance from the extremes, and she also knows that she is looking for a distance that is also valid for the extremes of the other segments. So, she wants to reproduce the construction of the perpendicular bisector made for segment AA' for the other segments. Ilaria's reasoning found favour with her classmates, who began to reason with her about the construction to be done to find the centre of rotation.

ST1's conclusion of the episode's analysis refers to the moment in which the teacher reacted to Ilaria's action on GeoGebra, displayed on the shared screen.

0:12:27 - 0:12:50 - While many in the class suggest how to proceed, Ilaria continued to work with GeoGebra. The teacher saw, via the shared screen, a new element in the construction and asked Ilaria what she has done. Ilaria replied: "I also put the perpendicular bisector of the CC' segment." The teacher continued: "Maybe we can also try the other segments and see if the midpoint is that one". Being aware of the properties of the perpendicular bisector and having realised that the centre of rotation must keep the distance from all the corresponding points, and not just to a pair of them, Ilaria drew two perpendicular bisectors. She observed that the point of intersection between the two perpendicular bisectors is precisely the sought centre of rotation.

Finally, ST1 highlights that the students' awareness comes through the focused interventions of the expert teacher. Indeed, she argues that "through the awareness of instructional goals, the teacher tries, with each of her interventions, to push students toward the goal, bringing to their attention the properties of the mathematical objects at stake".

Discussion

The episode that ST1 choose to perform her video analysis shows students' interactions with each other, with the teacher, and with the digital resource and highlights students' awareness of the properties of the rotation constructed in the previous phases of the teaching sequence. Moreover, the creation of the Timeline allowed ST1 to observe the importance of the teacher's role in conducting the collective discussion in accordance with the design and the aims of the teaching sequence. In particular, the detailed video analysis also allowed ST1 to realise how the verbal and non-verbal interactions between the teacher and the students resulted fundamental in the development of mathematical concepts. In her choice of the episode and in her TL we can recognise the effects of the collaborative task design. Thanks to the knowledge and the reflections developed during the PD program, indeed, ST1 became aware of the teacher's role that she sees to be "crucial in emphasising

that the point is not to be positioned randomly but must be found by exploiting the properties”. This can also be seen in ST1’s description of the first part (0:08:00 - 0:08:03) of the episode in which she pointed out the teacher’s awareness of the importance of Ilaria’s action with respect to the aim of the task: she highlighted that “knowing that this was the correct procedure, she invited Ilaria to explain what she was doing”. Moreover, ST1’s awareness of the role of the gesture in mathematics reasoning, allowed her to consider important also the iconic answers that Maria gave at the same time and in tune with Ilaria’s words. This choice was a consequence of the pre-service teachers’ discussions and insights developed during their collaborative work, so we can say that ST1’s interpretation of the episode was affected by the collaborative task design activities. The importance given by ST1 to the gestures as expressions of the students’ reasoning is evident also in the next parts of the episode (0:08:05 - 0:08:06) in which she felt the need to report on Ilaria’s metaphorical gestures. ST1’s comments here were still mostly related to the interpretation of what Ilaria was doing. However, they are the basis on which ST1 interpreted the teacher’s behaviour in the following part (0:08:20 - 0:08:48) of the episode. She highlighted, indeed, how the teacher’s behaviour was influenced by her perception of Ilaria’s reasoning on which she counts to make each pupil aware of the importance of the property recovered by Ilaria: “any point on the perpendicular bisector is equidistant from the segment”. ST1 again pointed out the role of Ilaria’s metaphorical gesture in emphasising the property verbally expressed. It is worth noting that the teacher’s approval of Ilaria’s reasoning was considered obvious by ST1 (0:09:00 - 0:09:15). This is because ST1 is aware of the importance of the property with respect to the aim of identifying the centre. At this point ST1 reported how the teacher interacted with GeoGebra, repeating to the whole class the property just recovered, and gave again Ilaria the floor. Here again ST1 interpreted Ilaria’s reasoning underlining that “she has realised that the midpoint of a single segment is not enough”. Her experience of collaborative task design influenced the following comment: “One more step, one more concept, is needed than that of the perpendicular bisector”. Indeed, she highlighted the most important aspects that Ilaria knows and interpreted her thinking: “she wants to reproduce the construction of the perpendicular bisector made for segment AA' for the other segments”. Then, ST1 interpreted the teacher’s behaviour as driven by the willing to bring the other students “to reason with her about the construction to be done to find the centre of rotation”. The intervention of the teacher –“Maybe we can also try the other segments and see if the midpoint is that one”– finally, is considered to be crucial in order to reach the aim. It was interpreted by ST1 as guided by Ilaria’s awareness of the properties of the perpendicular bisector and of the centre of rotation that “must keep the distance from all the corresponding points”.

Conclusion

In this paper, we presented, briefly analysed and discussed the results of a pre-service teachers’ professional development (PD) program focused on the use of technology. The aim was to show that pre-service teachers experiencing detailed video analysis of a teaching sequence that they have contributed to design, can build knowledge of how to interpret and reflect on teaching and learning episodes. The video analysis of the teaching-learning processes carried out by ST1 allowed her to closely examine what happened. Her interpretation of the episode was affected by the *external stimuli* obtained (e.g. the focus on gestures) and the *personal knowledge* built (e.g. the notion of Semiotic Bundle) during the program, by the *experience* of task design collaboratively conducted with the

other participants and by the *outcomes* that she could observe in the video concerning the evolution of students' thinking and the produced signs. At the same time, the reflection on the episode based on the detailed video analysis acted as a mediator in the four domains described by the Interconnected Model. Hence, it contributed to the professional growth of ST1, building knowledge of how to interpret teaching and learning episodes and creating the basis to learn what to do. Results are intended to be enlarged by considering the cases of other participants and developing a further edition of the PD program in which the final stage would also see pre-service teachers personally put into action a teaching activity.

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References

- Arzarello, F., Paola, D., Robutti, O., & Sabena, C. (2009). Gestures as semiotic resources in the mathematics classroom. *Educational Studies in Mathematics*, 70(2), 97–109.
- Clarke, D. J., & Hollingsworth, H. (2002) Elaborating a model of teacher professional growth. *Teaching and Teacher Education*, 18(8), 947–967.
- Dewey, J. (1910). *How we think*. Heath & Co.
- Faggiano, E., & Mennuni, F. (2020) Constructing mathematical meanings with digital tools: design, implementation and analysis of a teaching activity in a distance education context, *IxD&A Journal -Interaction Design & Architecture(s)*, 46, 156–174.
- Gaudin, C., & Chaliès, S. (2015). Video viewing in teacher education and professional development: A literature review. *Educational Research Review*, 16, 41–67.
- Li, Y. & Kaiser, G. (Eds.). (2011). *Expertise in mathematics instruction: An international perspective*. Springer.
- McNeill, D. (1992). *Hand and mind: What gestures reveal about thought*. Chicago: Chicago University Press.
- Mennuni, F., Cutrone, F. N., de Candia, M., & Marchese, G. (2021) Costruire il significato di rotazione: dalla formazione alla sperimentazione. In B. D'Amore (Ed) *Atti del Convegno Incontri con la Matematica n.35*, (pp. 215-216) Pitagora Editrice: Bologna.
- Mennuni, F., & Faggiano, E. (2020) Math education master students focusing on teaching mathematics with digital resources. In Donevska-Todorova A., Faggiano E., Trgalova J., Lavicza Z., Weinhandl R., Clark-Wilson A., and Weigand H-G. (Eds.) *Proceedings of the 10th ERME Topic Conference MEDA 2020* (pp. 85–92). Johannes Kepler University of Linz.
- Sherin, M. G., & Han, S. Y. (2004). Teacher learning in the context of a video club. *Teaching and Teacher education*, 20(2), 163–183.
- Zaslavsky, O. (2008). Meeting the challenges of mathematics teacher education through design and use of tasks that facilitate teacher learning. In B. Jaworski & T. Wood (Eds), *The international handbook of mathematics teacher education* (Vol. 4, 93-113). Sense.