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# Intertwining noticing and knowledge in video analysis of self practice: The case of Carla

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*This paper discusses a primary prospective teacher analysis of practice from a video episode she selected from her own practice – aimed at exploring the use of non-standard length measurement units. The analysis focuses on the revealed knowledge (MKT) while in practice, on the reflection when justifying the choice of the episode, and on her analysis of such episode. The results reveal aspects of PT knowledge associated with anticipating students' difficulties, but also her difficulties in interpreting and give meaning to student use of non-standard measurement units in a non-standard way. From the analysis, the need for an improvement in the use of video-based tasks in teachers' education is discussed, as well as the importance and impact of analyzing and discussing the analysis made by PT in and for educators' professional development.*

*Keywords: Mathematic teachers' knowledge, measurement, video analysis.*

## Introduction

Mathematics teachers' knowledge and professional development has acquired an important relevance for research, enhancing its complexity. Particularly, the research focusing on mathematics prospective teachers' (PTs) education brings to the fore the role and importance of the relationships between teachers' mathematical knowledge and their knowledge of the content and students (e.g., Ball, Thames, & Phelps, 2008). Following such focuses, new trends (conceptualization and implementation of interventions) for accessing, understanding, and developing teachers' and PTs knowledge are being developed (e.g., Ribeiro, Mellone, & Jakobsen, 2013; Santagata & Bray, 2015; Sherin, Linsenmeier, & van Es, 2009).

More recently, analyzing video episodes has been both a focus of attention and a source for teacher education (e.g., Llinares & Valls, 2010; Sherin & van Es, 2002). In that sense, the reflection and discussion upon one's own practice through video analysis is perceived as a powerful path for the development of a teacher's knowledge and awareness—focusing essentially on the mathematically critical features, both for teachers and students (e.g., mathematical content, competencies, interactions). One such critical aspect for students concerns measurement (e.g., Sarama, Clements, Barrett, Van Dine, & McDonel, 2011), particularly with regard to length. Considering the core role of teacher knowledge in student learning a focus on such knowledge is essential to better understand students' difficulties.

This paper aims at contributing to a broader and deeper understanding of the hows and whys sustaining the intertwining of teachers' knowledge (in the sense of Mathematical Knowledge for Teaching—MKT; Ball et al., 2008) and professional competency of noticing (in Mason's 2002 sense). Therefore, the research question in this study is what kind of knowledge is mobilized by the teacher when analyzing students' interactions with the mathematical content in a videotaped episode

of measurement. For doing so, a video clip of a primary PT practice on length measurement is discussed, as well as her analysis of such video. The results reveal powerful trends concerning both the video analysis process as well as PT knowledge concerning length measurement.

### **Theoretical framework**

As in other mathematical topics (e.g., adding or dividing fractions), the understanding of the mathematical whys of the measurement process is not straightforward, the understanding of such process being much more complex than the process itself. Piaget (1972) mentions that acquiring the notion of magnitude requires going through different stages, from the use of words to express the magnitude (correctly) until one has the knowledge about the measurement of such magnitude. Going through such stages is not a straightforward path, and developing a broader and deeper understanding of the concept image and definition involved (in the sense of Tall, 1988) is a core aspect of such development.

Two aspects in measuring a length are crucial: the dimension and the distance. The dimension is connected with the use of physical resources, and the distance concerns the space between two points/objects. Although both notions are perceived in an intertwined and inseparable way, due to its nature, one can't approach them in a single identical manner with students (Clements & Stephan, 2004). Such a measuring process requires the choice of the unit to use and perceive the quantity of units (or unit parts) are needed (how many) to go from one point to the other. Ultimately, one would need to combine both processes in order to get a more approximated value for the considered magnitude. In that sense, measuring is linked with two core ideas: the inverse relationship between the size of the unit used/number of units needed and the need for using the same unit in the same process of measuring (e.g., Clements & Stephan, 2004), applying it using a certain algorithm. Measuring the length thus requires knowing the standard measure(s) used, as well as the differences from using different measurement units (e.g., hands, foot, fingers) and the possibility of using these non-standard measurement units in a non-standard way.

Teachers' MKT on measurement is essential for developing students' knowledge and awareness of the topic. Among the MKT subdomains, and due to the aim and context of the work reported here, we consider for discussion the Common and Specialized Content Knowledge (CCK and SCK) and the Knowledge of Content and Students (KCS) subdomains. For doing so, examples linked with length measurement are used. The Common Content Knowledge (CCK) is associated with the mathematical knowledge required by teachers, including being able to use the instruments to correctly perform a certain measurement, knowing that no empty space must be left, as well as that there shouldn't also exist any overlays (instrumental knowledge). In doing so, knowing what instruments to use (in the sense of standard instruments/measurement) for measuring different entities and the differences between the entities they measure is involved. It corresponds to knowledge of how to perform, assuming a user's perspective (knowing how to measure). Complementary to this CCK, following the MKT conceptualization, teachers are required to be in possession of mathematical knowledge specifically linked with the tasks of teaching (Ball et al., 2008). Such Specialized Content Knowledge (SCK) includes knowing the mathematical whys justifying the different measuring processes (considering all the stages mentioned by Piaget, 1972). In addition to requiring knowledge of the different ways of measuring different entities, from one side, teachers' knowledge should also include knowing the whys of using such different forms of measuring (and the associated units).

Complementarily, it should include knowing possible different units for measuring the same entity and the ways of doing so (e.g., length), as well as the whys associated with the use of (non)standard units. In that sense, such knowledge does not include only knowing the whys associated with the procedures, but also includes the concepts (both image and definition in Tall's 1988 sense) and the whys associated with such concepts (e.g., the inverse relationship between the size of the unit and the number of iterations needed). Thus, it corresponds to a core aspect of the knowledge that allows teachers to give meaning and interpret students' solutions and comments (part of the interpretative knowledge, e.g., Ribeiro et al., 2013) while in practice.

Both CCK and SCK (and HCK, although it is not discussed here) give support for teachers' developing their practice—conceptualizing and implementing the tasks, hearing students' comments, and interpreting them in order to decide the path to follow at each moment. Those decisions are also informed by the knowledge teachers have of their students' difficulties or what they consider easier.

Intertwining knowledge of the content and knowledge of the students' learning processes concerns the KCS. It includes knowing that one of students' difficulties concern the measuring process (e.g., the need for using units with different natures), which is related to the complexity of understanding the measuring process (e.g., Clement & Stephan, 2004). In such subdomain of knowledge, one can also include the knowledge allowing teachers to anticipate students' difficulties in differentiating the measurement instrument (non-standard unit, e.g., the hand) and the measuring unit, or on ways of using non-standard measuring units (e.g., using the finger length or width).

Recent research has shown the need for designing instruments/resources for teacher education allowing them (and the researcher) to characterize the knowledge in action when analyzing their own practice (e.g., Kersting, Givvin, Sotelo, & Stigler, 2010). One such resource is video analysis (of classroom episodes), which allows a focus on how and which knowledge (prospective) teachers bring to front when interpreting, analyzing, and reflecting upon the recorded interactions (e.g., Kersting et al., 2010; Van Es & Sherin 2002). When focusing on selecting and characterizing a video episode, Sherin et al. (2009) consider three dimensions: (i) window, (ii) depth and (iii) clarity. In the particular case we address here, focusing on length, windows dimension is related to evidences of students' different levels of comprehension of the measurement of length; depth dimension is related to evidences of interactions in which students participate in the decision making process about choosing the measuring unit, the instruments and the measurement procedure and clarity is related to evidence of student's arguments that transparently show their comprehension of measurement of length.

Reflecting upon what seems to be happening, and discussing grounded on the analysis elaborated, is perceived as a pathway for developing teachers' knowledge and professional noticing (Sherin et al. 2009). Such professional noticing includes identifying what is important in a teaching situation, using what one knows about the context to reason about a situation, and making connections between specific events and broader principles of teaching and learning (Van Es & Sherin, 2002). Such noticing is thus linked with the ability for examining practice pinpointing the significant aspects in order to be better informed at the time of making their pedagogical decisions.

### **The context of the study**

Aiming at identifying and deepening the understanding of the content of teacher knowledge and how it intertwines with teacher actions and beliefs several case studies have been developed – in different

contexts and involving different school levels, mathematical topics, and competencies, contributing also to conceptualizing tasks of different natures focusing on developing teachers' knowledge (e.g., Ribeiro et al., 2013).

## Method

We first present the participant of this study, and afterward, the specific context and analysis stages and process. Here we focus on the knowledge and awareness about the topic of length measurement of a primary PT (Carla), who was part of a bigger research project in which her professional development through video analysis and reflection was the aim. Carla was in the last year of the teachers' training program at University Autònoma of Barcelona, and she was teaching the field practice to grade 2. Previously, she had some training concerning classroom analysis, identifying and interpreting relevant events in a video from a novice teacher. As part of the field practice, PTs have to record the 10 classes they teach (one hour each) and choose one episode to analyze and reflect upon – which has to be transcribed. The selection of the episode needs to be justified, mentioning the whys associated with its mathematical richness and referring explicitly to the mathematical goal pursued. For selecting and analyzing such an episode, Sherin et al.'s (2009) criteria (windows, depth and clarity) should be used (which have been previously explored with the PTs). Therefore, the analysis should focus on the mathematical content approached, student-teacher interaction, and students' understanding.

For selecting the episodes, PTs' were advised to look for situations they perceived as involving a "high level" of students mathematical knowledge and discussions/argumentations. Carla's choice was an episode aimed at introducing "the measurement of the length and width of objects using non-standard units" (e.g., the length of the classroom using the foot; the length of a glue package using the finger). An example of the proposed tasks is: using an unconventional length measure (finger), determine the length of the glue package. Although Carla chose a 15 minutes long video associated with the goal "review the content," she only considered it important to analyze and reflect upon the last six minutes – sustaining such choice on her perceived richness, in terms of Sherin et al.'s criteria (2009). In the video, one can perceive how the students assign the corresponding number (amount of units) to the length or width of the objects as a result of comparing such amount with the unitary measurement they consider as a reference. In the discussion, the inverse relationship between the length to be measured and the unit used is also explored. Complementary to the video and Carla's analysis, Carla (as all the other PT) were also asked to justify (in a written form) their actions in the video they selected.

The analyses were made in different stages and each of them followed the same structure. First, each researcher focused on the divergent aspects, then there was a joint discussion focusing on them. Such joint discussions contributed to a refinement of the analysis and increased the researchers' own mathematical awareness and "interpretative knowledge." Here we expand the notion attributed to this expression by Ribeiro et al. (2013) by including the researcher's ability to read, hear, and understand the interactions and knowledge in action. The first stage focused on analyzing Carla's revealed knowledge in the part of the video she considered important to analyze and reflect upon—the last six minutes. In the second stage, the focus of attention was Carla's analysis of her own practice using the same criteria PTs use for doing the analysis (Sherin et al.'s 2009 criteria). The third stage focused on the mathematical aspects associated with what happened in the first part of the video—which Carla

chose not to include in her analysis—and the possible whys concerning her knowledge and awareness leading to such choice.

### **Analysis and discussion**

When analyzing Carla's practice (the 15' video) with a focus on the CCK, SCK, and KCS, different aspects of her revealed knowledge are identified that sustain her awareness and professional competency of noticing. She reveals knowing the importance of measuring with different non-standard units (CCK), leading to the inverse relationship between the number of units and the size of such units (CCK):

*Carla: I gave an example, showing to the students that is not the same measuring with bigger or smaller hands, so I put my hand in the sheet they had to measure and asked a student to put his hand next to mine, to compare the different measures of both hands, telling them: "Do you see that his hand is smaller? Then my measure will be smaller than his".*

Also, the students' difficulties in measuring without leaving empty spaces between units is anticipated (KCS) when interacting with students:

*Carla: Of course, another thing is how we put our hands. If some of you put them like this (partially opened) and some of you put them as Isaac did (completely opened), Isaac will get less . . . But it doesn't mean that it is wrong; it simply indicates that we have different hands and we have measured differently.*

However, we can see a potential conflict identifying the unit of measurement, arising at least four different possible unit combinations: kin's and teacher's hand, both in a close or open position. In spite of Carla's ability to identify the previous situation as an interesting topic to be discussed in the class (noticing), it is noteworthy that there is a lack of awareness of the necessity of exhaustiveness when re-covering the measurable object (Clements & Stephan, 2004).

While teaching, Carla indistinctly uses dimension and distance—the two aspects of length (Dickson, Brown, & Gibson, 1991)—revealing aspects of the content of teachers' knowledge that need to be a specific focus of attention in training. Such knowledge would sustain the conceptualization and implementation of tasks aimed explicitly at exploring both concepts and their complexity. Not overcoming such difficulties, and thereby enriching teachers' SCK on measurement, would contribute to a low level of professional competence of noticing, particularly concerning the students' difficulties in distinguishing perimeter and area (and volume)—KCS.

Focusing on her analysis of the students' reasoning (only the last six minutes of the video), the fact that she can differentiate various aspects of understanding from different students reveals Carla's (advanced) level of professional competency of noticing according to Sherin et al.'s (2009) criteria. Such can be linked with her KCS as well as her interpretative knowledge (Ribeiro et al., 2013). In that sense, she takes into consideration (CCK and SCK) the dimension, the absence of empty spaces between the use of the measurement units, the use of anthropomorphic units, and the inverse relationship between the size of the unit and the number of iterations – on the written justification Carla wrote: *Hugo and Daniel notice that the different results of the measurement depends on the size of the hands; Miguel, on the other hand, concludes that the result depends on the ways the hands are placed).*

When justifying the choice of the episode to analyze, Carla's reflection reveals an awareness of the relationship between the SCK on the content, her decisions, and her ability to anticipate the students' difficulties and understanding of the topic (KCS).

*Carla: I chose this particular part of the class because it reveals the moment when the pupils become aware that when measuring with non-standard instruments and units, they get different results... Through the students' reflection and reasoning, they get that the size of the hands matter when measuring the length (thus getting different results) and that not only the size of the hand matters, but also the ways one uses it. I also have to note that after the mentioned reasoning emerged from students, I registered the different values on the blackboard, and I could then use it to explain to the whole class. During this period, I also use different teaching strategies, including the registration on the board (with the number and the unit used), giving time for students to present their results, and promoting reflection concerning the measurement technique used, supported by visual examples, as they could have difficulties in the content concerning both the measuring process and finding the relationship between length and units used.*

However, in the remainder time of the episode Carla didn't chose to analyze (the first nine minutes), something curious and mathematically important happened. Analyzing it can shed some light on teacher decisions and associated specialized knowledge as well as concerning the need for a change in Sherin et al.'s (2009) criteria for selecting and analyzing he video episodes.

During the first part of the episode, one student (Miguel) provides a completely different answer to the posed questions (e.g., length of the class in steps, when the rest of the class provided answers around 30, his answer was 14). Carla interpreted it as a misunderstanding of the measurement process, showing him in each case "how to do it correctly." But the consistency of Miguel's answers reveals a high level of understanding (concept image and definition, Tall, 1988) of measurement (Clements & Stephan, 2004), using non-standard units. When Carla discussed the question "How many fingers are needed to measure the glue package?" Miguel again disagrees with the other students and with Carla's validation of a length of eight fingers. With the glue package on the top of the table, on the vertical, the following dialogue occurs:

Teacher: *No? How many fingers did you get?*

Miguel (putting the finger vertically along the glue package): *One!*

Teacher: *One? Like this? (The teacher repeats the measurement process using the indicator finger horizontally)*

Miguel: *No, two...*

Teacher: *Two? With two you can cover all the distance?*

Miguel: *No...ah...four...*

Teacher: *Don't know what you are measuring...*

Miguel: *Ah, four, four...*

Teacher: *No! It can't be...you should get eight, you are doing it wrong.*

Although the goal of the class was “*to use non-standard length measures,*” such measures have been used and explored by Carla only in a standard way (the one with which she was used to – taking into consideration the cultural aspects). Such exclusive use, linked with the content of SCK, makes it difficult to anticipate and understand (KCS) Miguel’s answers—use of non-standard measurement units in a non-standard way. The fact that when reflecting upon her practice and analyzing the video she did not point to this aspect as problematic sustains the need for a change in the way the video analysis task has been conceptualized. And, in an intertwined way, makes us wonder about Sherin et al.’s (2009) criteria for professional competency, as when focusing only on her own analysis (of the last six minutes), Carla could have been considered to have an advanced level of such competence; when looking at the part of the video she did not analyze, a different conclusion could be drawn. In that sense, there is also evidence of the interdependent nature of such competence and teachers’ knowledge.

Carla seems to not be aware of the inexplicit use of a one-dimensional measurement unit on a three-dimensional object, leading thus to some contingency moments. To overcome such moments, she opted (grounded in her own revealed knowledge of measurement) to tell the student “how to do it”. Although aspects of professional awareness and competencies of noticing are present both in her practice and in her analysis of the video, her knowledge shaped such aspect, leading to a partial view of the students’ understanding of the measurement length and units. This supports the need for a complementary discussion and reflection upon the video analyses PTs make in order to focus also on the mathematically critical aspects they are not aware of, and which are a barrier to completely achieving the advanced level of professional competency of noticing expected when using Sherin et al.’s (2009) criteria.

## **Final comments**

From the work focusing on the video analysis, three aspects can be enhanced: teachers’ knowledge and professional noticing abilities; reflection and awareness capabilities; video-based task design and its potentialities. Although of different natures, these aspects have in common the educator’s responsibility in changing the training process. Through this case study, one can better understand aspects of the content of the different subdomains of MKT, both revealed in practice as well as expressed when reflecting upon such practice when analyzing the video. Other aspects concern the impact of the interactions and the prevalence of non-standard length measurements in standard ways, and that revisiting the practice didn’t become a prompt for awareness and noticing development, obviously linked with previous experiences and MKT. This calls our attention to the need for an exterior element to pinpoint these critical features, leading them to become a starting point for developing such knowledge and awareness.

Although the video analysis performed by Carla with the provided instrument did not accomplish completely the defined aim, our analysis of her practice and of her own analysis of the video was a prompt for inquiring our own practice as educators in terms of interpretative knowledge (Ribeiro et al., 2013) and of awareness of the educators professional noticing abilities. One future research path concerns thus the develop of a complementary instrument for video analysis that would allow trainees

to dig deeper into their awareness of the mathematical whys sustaining what happens and to focus also on the educators specialized knowledge, awareness and noticing abilities.

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