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The study attempted to investigate the ways a prospective teacher, Elif, responded to contingent moments in her teaching practice. In addition, her perceptions regarding changes in the nature of the tasks based on the students' unanticipated thinking after the teaching were examined. Elif attended to a two-hour class of teaching seminar in which categorizations of mathematical tasks were presented. Then, during her enrollment in teaching practicum course, she taught a lesson on algebra by considering the categorization of the tasks. The lesson plan, her video record of teaching, semi-structured pre and post interviews were analyzed based on contingent trigger categories and kinds of teachers' responses to them and tasks during the phase of selecting, enacting and revising were analyzed based on its cognitive demand. Results showed that the contingent moments lead her to reanalyze the content and implementation of the designed tasks for further teaching.

Keywords: Specialized Content Knowledge, Knowledge Quartet, Contingency, Pre-service teachers, Cognitive Demand

Introduction

A mathematical task (i.e. a problem or a set of problems) is "a classroom activity, the purpose of which is to focus students' attention on a particular mathematical idea" (Stein, Grover, & Henningsen, 1996, p. 460). The teacher's pedagogical knowledge in planning lessons has a crucial role in the way mathematical tasks are selected and implemented (Stein, Grover & Henningsen, 1996). Thus, designing tasks based on students' understanding and identifying students' ways of thinking during task implementation as parts of teachers' knowledge are important abilities for effective teaching (Fernande, Llinares and Valls, 2010). Hence, as Chapman (2013) stated, during practice teachings, focus be placed on pedagogical knowledge regarding the nature of task.

In the context of task implementation, eliciting students' ways of thinking has become an important skill for teachers during practice teachings. Rowland and Zazkis (2013) concluded that "a teacher's responses to problematic contingent moments that arise in teaching mathematics are fundamentally dependent on their mathematical knowledge, which prompts and guides pedagogical implementation" (p. 151). It is a fact that due to the nature of the learning environment, which is dynamic and complex, teachers as well as novice teachers encounter many challenges in responding to student needs (Foster, 2014). Hence, teachers should be well prepared for such potential contingent situations and moments for the following teaching practices (Rowland, Thwaites, Jared 2015). Thus, the present study aimed to reveal the novice teacher's knowledge regarding the contingencies so that mathematics teacher educators can have a better understanding of novice teachers' pedagogical knowledge (Liston, 2015).

Hence, the study initially attempted to examine how a preservice teacher responded to these contingent moments.

Not only declining or maintaining the cognitive demand level, but also transforming tasks with lower cognitive demands into high-level tasks are closely linked to students' ways of thinking and teachers' decisions at contingent moments. At a more detailed glance, teachers' decisions regarding the nature of a task and sequences of tasks are shaped by students' opinions and their ways of thinking at the moment that is related to active facet of contingent knowledge. Moreover, proactive aspect (Hurst, 2017) of it includes teachers' planning of task design where they seek to address students' misconceptions. Hence, eliciting students' ways of thinking and unexpected responses might ensure effective task implementation and design. In this respect, it is believed that experiencing 'Contingency' instances may provide novice teachers with opportunities to improve their pedagogical knowledge (Rowland, Thwaites & Jared 2015) by transforming tasks into high-level tasks or maintain tasks' cognitive demand. Hence, the second aim of the study was to explicate how these contingent moments guide teachers in thinking about the nature of the tasks implemented. This is important since research needs to identify how the opportunity of contingent moments and knowledge in features of the level of the tasks support teachers' ways of altering tasks in following teaching practices. Thus, the research questions of the present study were stated as follows: (1) How does a novice mathematics teacher respond to contingent moments during her teaching of algebra? (2) How do contingent moments help the preservice teacher to reconsider the nature of the task for further teaching?

Theoretical Framework- Knowledge Quartet Model (KQ)

An empirical framework called as Knowledge Quartet developed by Rowland, Huckstep and Thwaites (2005) has been used to assess and develop both pre-service and in-service mathematics teachers' mathematical knowledge during planning and teaching. It comprises four main units; namely, foundations, transformation, connection and contingency. The last component of the knowledge quartet, *contingency*, is described as 'the "opposite" [their emphasis] of planning – to situations that are not planned and that have the potential to take a teacher outside of their planned route through the lesson' (Rowland and Zazkis, 2013, p. 139). Contingency is concerned with a teacher's ability to make convincing, meaningful responses to unanticipated student answers, questions and statements. "Responding moves", similar to *contingency,* are regarded as key moments in organizing a lesson (Brown & Wragg, 1993). Based on the model, contingent moments are associated with the codes of "responding to students' ideas; deviation from agenda; teacher insight; (un)availability of resources" (Rowland, Turner & Thwaites p. 4). Therefore, in this study, we first identified contingent moments in the video recording of the pre-service teacher's instruction and then analyzed whether or not the teacher attended to those moments, and how she reconsidered the nature of the tasks based on those instances.

Within the context of the mathematical tasks, the Mathematics Tasks Framework characterizes three phases through which tasks pass: first, as they are in the curricular materials; next, as tasks are set up by teachers; and last, as they are applied by students in the classroom (Stein, Grover and Henningsen, 1996). All these are believed to have an important impact on students' learning process. The cognitive demand of mathematical tasks emphasized in the second phase of the framework refers to “the cognitive processes students are required to use in accomplishing [tasks]” (Doyle, 1988, p. 170). It is classified into four categories, which are memorization, procedure without connection, procedures with connection and doing mathematics (Stein et al., 2000). Tasks with a low cognitive demand (memorization and procedure without connection) require students to memorize facts, rules and procedures without relational and conceptual understanding and do not lead students to engage in high-level mathematical thinking, such as problem solving, reasoning, connection and critical thinking (Stein & Lane, 1996). On the other hand, mathematical tasks with a high level of demand include multiple entry points rather than a single answer. In other words, high level tasks entail explorations of mathematical ideas by thinking critically and reasoning.

Although researchers emphasized that the high-level tasks are key to acquiring mathematical ideas (Stein, Grover, & Henningsen, 1996), tasks themselves, even high-level ones, may not result in high level understanding. At that point, the role of the teacher during the preparation and implementation of mathematical tasks have emerged as a crucial aspect in teaching mathematics conceptually (Doyle, 1988). Indeed, teachers should be responsible for changing the cognitive demand of tasks during classroom implementations (Smith, Grover &Henningsen, 1996). Hence, teacher knowledge could be regarded as one of the important factors impacting teachers’ way of altering task features to meet student needs.

Methods

Context and Participants

The case study research methodology is used to respond to “how” or “why” questions in detail (Yin, 2013). Since the main aim of the study was to analyze and reflect on complex classroom practices, the responses to the research questions of the study were sought by utilizing the single case study methodology. In a project, six novice teachers were selected based on their willingness to participate in the study and on their high-level of achievement in the teaching method courses. The participants were provided with a (two-hour) seminar on the Smith and Stein’s categorizations of mathematical tasks. The seminar was held to familiarize them with each level of the cognitive demand of the tasks. It was believed that this familiarity would enable them to critically analyze the features of the tasks with respect to how students think and present mathematical opinions. Subsequent to the seminar, they were expected to prepare a lesson plan including tasks with a low or high level of cognitive demand. Elif, a novice mathematics teacher, volunteered to teach a class; therefore, Elif’s lesson was selected for the present case study.

The pre-service elementary mathematics teacher, Elif, was in her fourth year at a public university in Turkey. Thus, Elif had completed Teaching Mathematics Method courses and Practice Teaching I course aiming at providing an opportunity to observe teachers’ the way of teaching and student learning. In addition, she was experiencing the teaching for the course of Practice Teaching II (practicum). She planned lessons to meet the requirement of Practice Teaching II (practicum) and we focused on one of her lessons.

Data Collection and Analysis

The lesson plan, video recordings of her lesson and the audio-record of the semi-structured pre- and post-interviews were used as data sources. The pre-interview lasted 50 to 70 minutes in a one-on-one setting to determine her perceptions regarding the nature of the tasks selected for the lesson and her opinions regarding unexpected ways of student thinking related to the tasks. After her lesson, she was asked to observe the video of her teaching by using the classification features of cognitive demand tasks as a guide. Finally, we performed a semi-structured post-interview to gain information regarding her views on the way she responded to contingencies and redesigning the task. Sample questions from the post-interview are as follows: "How would you deal with that response?" The tasks as data in the processes of planning, acting and revision were analyzed using the cognitive demand levels in the mathematics task analysis guide (Stein et al. 2000). In addition, the lesson episodes including the implementation phase of the first and second tasks were transcribed and then analyzed based on the contingent trigger categories of Rowland et al. (2015) and different kinds of teachers' responses to them.

Overview of Elif's lesson

Elif taught algebra for 7^{th} grades. The learning outcome of the lesson required learners to be able to describe how two variables having linear relationship with each other vary by using table, graphic and equations. There were 22 students in the class, 12 boys and 10 girls. They were seated at tables in front of the board and Elif stood at the board and walked around the seats for some time. The lesson started with a task at the level of 'memorization'. More specifically questions: "what is the meaning of linear relationship?". Then Elif continued with the second task which was related to the relationship between two variables varying together designed at the level of 'procedures without connection' provided below.

Interpret the changes in volume of the beaker and time.

Figure 1: The Second Task

Findings

Contingent moments emerged during enactment of the first task and Elif's responses to the moments provided as follow:

Linearity: Speed, Time and Position

After Elif presented the first task to the class, three or more students defined the linearity between two variables and then two of students mentioned speed and time. She accepted the responses and got students to think of the relations among those variables, namely time, speed and distance, as in the following conversation:

Elif: Yes, speed increases as time increases, right? Or is speed constant?

Student 1: Speed can change; for instance, the speed can be 61 km/h during half of the distance. Then, the car can go at 59 km/h during the other half of the distance. Then, the speed will be 60 km/h and [hence] constant.

Elif: Do you think that speed is constant as time increases, or speed increases as time increases. Which one?

Student 1: Overall, the speed did not change.

However, some responded by saying “Constant”.

Elif: Now consider that time increases, and speed is constant. Only one variable is changes. Yes? So, what does linear relationship mean?

Then she drew a graph of time versus speed (speed is constant) and explained that speed had one value as time increased. Then she asked a question “Is this a linear relationship?” by pointing to the graph. One student responded by saying, “it [the value for y-axis] might be distance.” Then she drew the graph of time versus distance when speed is constant, and she continued to say:

Elif: If we go back to the speed example, should the speed increase in time? How does speed change? Is it constant, increases constantly or how?

Student 2: It should be [increasing] at certain intervals. 60,120,180…

Student 3: Certain ratios

Elif: Yes, another example?

Student 1: [For instance] the pupil read 10 pages of a book on the first day, and on the second day the pupil read 20 pages of the book?

Elif: [By interrupting the student’s speech] If I said there is a linear relationship, it should be increased by certain ratios or number. [By pointing to the second speed versus time graph] Do you understand now why I cannot say that there is a linear relationship?

This contingent moment related to confusion in the concept of constant rate of change arose based on students’ responses to the first question and students’ spontaneous responses during the discussion. The response of Students 1 led Elif to hold a discussion on the linearity of variables in the context of time and distance. During the post-interview based on the first task, Elif stated that she had not expected such an example as time and speed instead of time and distance; hence, she was confused.

Elif channeled students towards considering the one possible correct example that as time increased, distance also increased in the condition when speed was constant. Thus, this might indicate that she acknowledged the opinion of Student 1 regarding the ‘linear relationship between the average speed (speaking of two constant speeds) and time’, but it was ignored, perhaps because Elif did not understand the student’s idea and its relationship with linearity or she was challenged in elaborating the misconception. During the discussion, despite Elif’s directions, some students responded to the question by saying that the relationship between the time and speed was linear. She did not attend to those responses either, and she stated in the post-interview that her focus was solely placed on receiving distance versus time as a correct answer from the students. In this regard, it could be inferred that Elif focused on receiving the same answer that was on her own mind and was not open to any other alternative response.

Linearity: Graphs

The second contingency and Elif's response to it was as follows:

Student 1: [The line in] the graph must pass through the origin. Right?

Elif: No, it is wrong, in our examples there can be a starting point.

Student 1: How?

This unanticipated situation was related to the student's tendency to create a graph with a line passing through the origin for linearity. The teacher addressed the student's unexpected opinion by correcting it. However, the opinion was not discussed by using any representations. She presented the reasons for her action during the post-interview by saying she did not how to combine the situation with their graphs, and thus, judged the idea as being unworthy for discussion in the class. The changes in the first task recommended by Elif are presented under the next heading.

Perceptions on Modifying the Task

Two contingent moments and Elif's reactions to those moments have been described above. During the post- interview, Elif suggested changes in the properties of the task, in its the sequence, and the time allocated for the task, as can be observed in the following conversation:

Interviewer: If you had the chance to apply these tasks, how would you deal with that response?

Elif: The task: "Consider that a bus arrives at each station at each station at exactly the same time duration and the distance between each station is the same. Explain the relationship among the variables (distance, time and speed) in this situation". Then "If my speed or distance is not zero at the beginning, could we speak of similar relationships among the determined variables? Justify your examples by drawing graphs [of the quantities]".

As can be understood from the above conversation, the teacher had to ask follow-up questions to get students to consider the situation. Moreover, she had to focus on representation of the variables graphically. Moreover, Elif underlined the fact that the first and the second tasks, which were at the level of 'memorizations' and 'procedures without connection', respectively, could be merged, and there was no need to have students do the second task since the concepts of time, speed and distance were great a opportunity for discussion. By integrating the contingent moments and the properties of tasks with a high cognitive demand level, the teacher wanted to redesign the task requiring a higher level of cognitive effort and students to use representations. With the assistance of the guide, she critiqued her tasks based on whether the revised version was coherent with respect to the properties of the tasks with a high level of cognitive demand and different from the properties of the ones with a low level of cognitive demand. For instance, she believed that she expected students to become aware of the meaning of the linear relationship in the context by leading them to use appropriate representations instead of giving them an algorithm or memorized facts (the definition of linear relationship). Thus, the task was coded as one with a higher-level demand.

Discussion

The present study yielded the emergence of two contingent moments associated with *trigger type 1: responding to students' ideas,* proposed by Rowland et al. (2015). The moments were related to students' incorrect examples for linearity that stemmed from their misinterpretation of the degree of change and students' tendency to sketch graphs of variables having linear relationships with a line passing through the origin. During the pre-interview, Elif did not mention these students' possible opinions since she believed that low level tasks required limited cognitive demand and were solved by means of utilizing procedures, and she expected the students to give the definition of linear relationships as the correct answer. As the students presented different ideas related to linearity during the implementation of the task, the teacher was not able to effectively monitor and reflect different student ideas. Hence it could be stated that she had a perception that cognitive demand of a selected task did not change during the enactment of the task.

The findings related to the teacher's response to these unanticipated moments revealed that Elif became engaged in some of the students' unexpected answers, but she directed students to think only of the time versus distance example. In addition, during the classroom discussion, Elif did not attend to students' ideas; however, focusing on these ideas could have resulted in students' conceptual understanding of the mathematical idea (linearity). Combining this finding with the claim that the nature of teaching in real settings is dynamic and complex, we concluded that as a novice teacher, she was incapable in handling these moments occurring in the classroom (Foster, Wake & Swan, 2014) and could not make use of the opportunity of the unanticipated instances. For this reason, it could be maintained that she might have an answer-oriented approach that teachers rely on short recall questions and leading questions to guide students to the solely correct answers (Moyer & Milewicz, 2002) although she tried to increase the cognitive demand of the task by drawing the graphs. It could be claimed that her mathematics knowledge for teaching, a crucial factor for task implementation (Stein, et al, 2000), was weak since she could not give meaning to mathematical procedures (e.g. Charalambolous, 2010).

Although Elif was not able to orchestrate the discussion and she lacked in responding to unanticipated moments occurring during her teaching, she emphasized a need to change the nature and structure of the task addressing the second research question. In other words, these moments presented an opportunity for her to become aware of the different ways of student thinking that is concerned with proactive facet of contingent knowledge. Hence, it could be deduced that Elif benefitted from her experience (Rowland, Thwaites, Jared 2015). Moreover, the guide for task classifications was beneficial for redesigning the task for further teaching. Besides, the paper particularly provided insight into the fact that contingent moments triggered preservice teachers towards improving their low-level tasks and reconsider the sequences of the tasks, and this may, in turn, enhance their knowledge of mathematical tasks. In the light of the study, it could be claimed that more exposure to contingency moments through video clips by knowing the classifications of the mathematics tasks within the scope of the teaching practice courses can prepare pre-service teachers to actual classroom environments. In conclusion, the study contributed to the literature with information regarding the impact of contingent moments on the implementation of low-level tasks. However, analyzing data of merely two low level tasks and basing the study on the reflections of one pre-service teacher could be regarded as the limitations for the study. Hence, further studies are needed to portray the relationship between unanticipated student responses and the ways that pre-service teachers achieve high cognitively level tasks.

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