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Development of Pre-service Middle School Mathematics Teachers' Skills in Interpretation of Student Thinking in the Context of Lesson Study

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Abstract: Mathematics teachers' knowledge of students' thinking has an important effect on the teaching-learning process (Cai, Ding & Wang, 2014; Clarkson & Presmeg, 2008). Teachers who understand student thinking sufficiently can interpret student thinking effectively and can anticipate student misconceptions, difficulties, and errors. Furthermore, they can overcome these challenges with appropriate explanations (An, Kulm & Wu, 2004; Ball, Thames & Phelps, 2008). The research revealed, however, that teachers/pre-service teachers have difficulty interpreting student thinking (Crepso, 2000; 2003). This led to the conclusion that pre-service teachers need to develop skills in understanding and interpreting the student perspective (Hiebert, Morris & Glass 2003). The scope of this study was to improve pre-service middle school mathematics teachers' knowledge and interpretation of student thinking through lesson study. Three senior pre-service teachers participated in this study. Pre-service teachers implemented three practice lesson study cycles in a real classroom. Data was obtained from documents, video recordings, observations, field notes, and reflective papers. In order to analyze data, content analysis was used. Results showed that the pre-service teachers had some challenges knowing and interpreting student thinking at the beginning of the study. As lesson study cycles proceeded, pre-service teachers began to take into account student thinking, design and implement lesson plans according to students' needs and difficulties.

Keywords: Teachers' knowledge of students, Discussion skills, Lesson study

Introduction

The knowledge of the teacher in the effective teaching of mathematics is undoubtedly a key point. Although there are many kinds of knowledge that the teacher should have, the common point on which researchers agree is that the teacher should have a good subject-area and pedagogical knowledge (Ball, et al., 2008; Shulman, 1986). This knowledge has been detailed in itself, and student knowledge has attracted attention as one of the important types of knowledge that teachers should have (Ball et al., 2008; Doerr & English, 2004; Grossman, 1990; Shulman, 1986). Student knowledge includes teachers' knowing students' prior knowledge, ways of thinking, mistakes, misconceptions or difficulties (An, et al., 2004; Ball et al., 2008; Hill, Ball & Schilling, 2008, Shulman, 1986). Both in Turkey and abroad, the teachers' having information about students is considered to be an important competence and it is argued that teachers' having this knowledge directly affects the quality of the teaching process (Ministry of National Education [MoNE), 2017a, 2017b; National Council of Mathematics [NCTM], 2000). Research has shown that teachers who have sufficient knowledge about students can effectively construct their teaching (Carpenter, Fennema, Peterson, Chiang & Loef, 1989; Fennema, Carpenter, Franke, Levi, Jacobs & Empson, 1996; Franke & Kazemi, 2001). However, the existing research has also revealed that both teachers and pre-service teachers have various difficulties related to student knowledge. Some of the difficulties experienced are that they cannot anticipate how their students think, are inadequate in answering students' questions and cannot interpret students' answers (Bergqvist, 2005; Crespo, 2000; 2003; Driel & Berry, 2010; Empson & Junk, 2004; Kılıç, 2011; Hadjidemetriou & Williams, 2002; Nathan & Koedinger, 2000; Tirosh, 2000; Wallack & Even, 2005). Researchers emphasize the need for teachers, particularly for pre-service teachers, to overcome these difficulties experienced in relation to student knowledge

(Crepso, 2000; 2003; Kılıç, 2011; Tirosh, 2000). To this end, training programs have been organized to support the development of pre-service and in-service teachers' student knowledge. In these programs, student thinking has been taken to the centre, and discussion environments have been created through case studies and videos (Berk & Hiebert, 2009; Carpenter et al., 1989; Clarkson & Presmeg, 2008; Fennema, Franke, Carpenter & Carey, 1993; Schorr & Lesh, 2003). It is emphasized that the training programs that will support the development of pre-service teachers' student knowledge should allow interactions with students in the real classroom environment and include reflection on instructional practices (Ball & Forzani, 2009; McDonald, Kazemi & Kavanagh, 2013; McDuffie, 2014). As the lesson study approach includes these features, it can be used to support the development of pre-service teachers' student knowledge. In this connection, the current study aims to develop the pre-service middle school pre-service teachers' student knowledge through lesson study applications.

Method

The current study employed the case study design, one of the qualitative research methods. The case study allows in-depth investigation of the target problem (Cresswell, 2013). The participants of the current study are three senior students attending a state university in the city of Ankara. The pre-service teachers conducted three lesson study. The pre-service teachers planned their lesson as a group and this lesson was delivered by one of the pre-service teachers in a real classroom environment. Meanwhile, the other pre-service teachers, the researcher (1st author) and the teacher took observation notes. After the completion of the implemantation, the lesson was evaluated by the teacher and the researcher. After the evaluation, the pre-service teachers revised their lesson plans and gave their final forms. This cycle is illustrated in Figure 1. In this way, the pre-service teachers conducted three lesson study applications to address the 7th grade course objectives "Form the pie chart of a data set and then interpret it", "Form the line chart of the data and then interpret it", and "Depending on the type of the data collected for the research questions, select a pie chart, frequency table, bar chart or line chart to display the data and then make conversions from one chart type to another chart type", respectively (Mone, 2018). As the data collection tools, the lesson plans prepared by the pre-service teachers, video-recordings of the lessons delivered by the pre-service teachers, observations and field notes were used.

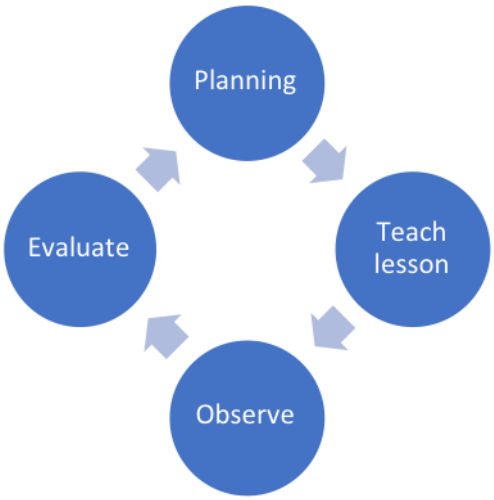

Figure 1. Lesson study process

In the analysis of the collected data, content analysis was used and by analysing the data related to student thinking in the instructions conducted by the pre-service teachers and the lesson plans prepared by them, the changes in the pre-service teachers' student knowledge were observed.

Results and Discussion

The results have revealed that the pre-service teachers have various difficulties in knowing and interpreting student thinking. The pre-service teachers did not pay much attention to student thinking in their lesson plans and implementations and provide inefficient explanations. For example, in the first lesson study, it was found that the pre-service teacher overlooked the difficulties that could be experienced by students in collecting data (see 1st lesson study implementation).

1st Lesson study implementation
"……..

Number of sibling	Number of person
0	3
1	9
2	6
3 and above	2

Gamze: ***Now, do you know how we found these data? As you know, we are studying in University A; I asked a specific number of friends in the class. These data belong to them****….."*

Here, it is seen that the explanation made by the pre-service teacher is insufficient. Moreover, the explanation made can lead to the formation of misunderstandings about the features of data collection.

The pre-service teachers were observed to be making greater effort to understand the students' statements in the 2nd lesson study implementation. On the basis of the students' statements, discussions were conducted on the target concept. For instance, one student gave an example related to the subject. On the basis of this example given by the student, the pre-service teacher drew attention to this target concept (see 2nd Lesson study implementation)
2nd Lesson study implementation
"……
Student: Can I ask a question? They are using at hospitals, it is used in this way
Şirin: Do you mean EKG?
Student: But, there is not written Monday or Tuesday.
Student: But they are ***for each heart beat; in fact, we do not have to write the day here. I can for example write the time here as well. For instance, here is the heart rate and there is the time or seconds. We can do like this."***

Here, it is seen that the pre-service teacher paid attention to what the student wanted to say and on the basis of the student's statement, she made an explanation about how the scaling should be done during the drawing of graphs. In the second lesson study implementation and particularly in the third lesson study implementation, the pre-service teachers were observed to have constructed their lessons by putting students' thoughts into centre of the class discussion. They addressed the point where the students could make excessive generalization with the activities they prepared (see Figure 2).

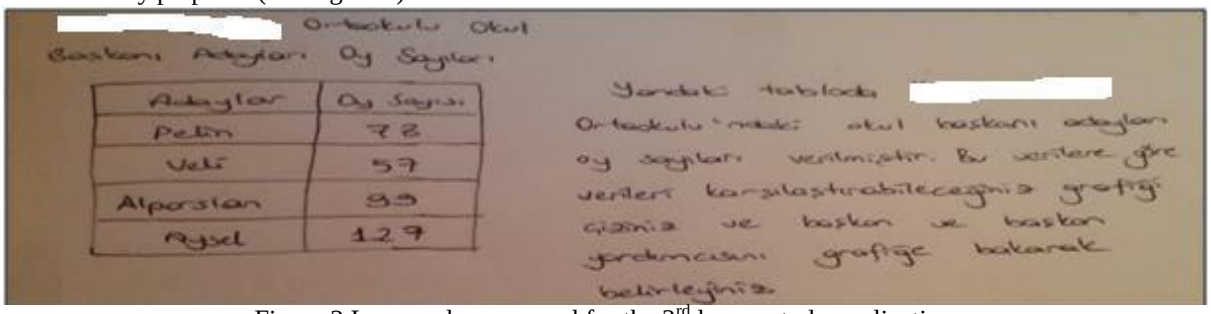

Figure 2 Lesson plan prepared for the 3rd lesson study application

When the pre-service teachers were talked about this activity they had prepared, they said: "*When the numbers of votes are given, it is always thought that a pie chart should be used. We selected this context on purpose and wanted them to learn that when necessary they can express these numbers with a line chart." (The 3rd lesson planning meeting).*
Furthermore, during the implementations, the pre-service teachers observed the students' works and on the basis of the difficulties experienced by the students, they attempted to help the students overcome these difficulties through the questions they asked. For example, Beyza realized that a group of students were comparing the role of the bar chart and line chart in answering the formulated question. Beyza tried to help them overcome this confusion with the questions she asked. The related conversation is given below.
3rd lesson study implementation
"…
Beyza: ***When I draw the bar chart what can I see?***
Student: You can find how many.

Student: How much it increased or decreased.
Beyza: ***Increased, decreased?***
Student: No, it is in the line chart.
Beyza: ***Isn't it, what is in the bar then?***
Student: How many, from example, are there from certain people.
Beyza: ***What can I see there?***
Student: The difference between them
Beyza: ***That is, we can look at the relationship between the bars, them. Then, you can write these. You can write how it is drawn or displayed.***
What can we look at in a line chart?
Student: Weather conditions, increase, decrease…"

When the discussion environment is evaluated, it is seen that some students experienced difficulties in understanding the idea that the question formulated should be taken into consideration while determining the suitable type of graph. Beyza's creating a suitable environment for a group discussion and evaluating the students' opinions led to elicitation of this difficulty. Beyza asked questions to help the student overcome this difficulty and gave students some time to think. In a similar manner, during the implementation, the pre-service teacher asked the question "*….Can show weight with a bar chart?"* The reason for her asking this question is making the students aware of the fact that though the weight is known as the constant variable, it can be displayed with a bar chart when necessary. The related conversation is given below.

3rd lesson study implementation
"….
Beyza: Can we show the weight with a bar chart?
Student: For example, if someone says us that the students in a class, let's say 26 kilograms at most, there are 9 students who are 26 kilograms.."
In the evaluation meeting, the pre-service teachers were talked about why they asked this question. The pre-service teachers stated that the concept of weight might be perceived as a constant variable; thus, they felt the need to ask such a question to prevent this perception to occur. This shows that the pre-service teachers considered the difficulties experienced by the students and carried out their applications to address these difficulties. Another point was recognized while the pre-service teachers were observing the students' works. Observing the works of a group, Beyza recognized that the students confused the angle measures of the slices in a circle with percentage. Then, she provided the following guidance to the students to realize their mistake:
3rd lesson study implementation
"…..
Student: We also multiple all by 5, then they become 20. But it is very small
Beyza: What do we multiply by 5?
Student: Because there are a total of 20 people here and we need to multiple by 5 to obtain 100 [Rather than taking the whole as 360, we think that it should be taken as 100]
Beyza: ***Okay, what are you writing inside the pie chart, now angle. What are we doing in the case of angle?***
Student: 360 then … I did it 100.
Beyza: ***Isn't it, did you realize it? What did your friend do?***
Student: He/she did it smaller.
Beyza: Why did he/she do it smaller?
Student: as 100 rather than 360 was taken.
Beyza: ***Why? Isn't it possible to make it 100?***
Student: as it is 360 degrees, not it cannot."

Here, we can see that the pre-service teacher realizing that while calculating the angle measures of the slices in a circle the students took the whole as 100 rather than 360 provided the necessary guidance for students to correct their mistake.

Conclusion

At the beginning of the lesson study implemantation, the pre-service teachers were observed to be inadequate in anticipating student thinking and in considering their answers. In the lesson planning meeting, they focused on typical student thoughts yet overlooked the points where students could have difficulties, make mistakes and develop misconceptions. It was even observed that the statements used by the pre-service teachers in the

applications they conducted could result in misunderstandings on the part of the students. In the literature, it has been revealed that there are some deficiencies in pre-service teachers' student knowledge (Bergqvist, 2005; Kılıç, 2011; Tirosh, 2000). With the progressing lesson study process, positive developments were observed in the pre-service teachers' student knowledge. They planned their lessons by taking the students' thoughts into consideration and they observed the students' works during the implemantations and when they detected a point where the students were experiencing difficulty then they provided guidance for the students to overcome this difficulty. When it was thought about the reasons for these positive developments, a few points came to the fore. First of these is the pre-service teachers' observing the students in a real classroom environment while conducting some applications. In this way, they obtained more detailed information about the students and could make comments on their way of thinking. In the literature, the positive contributions of working with real students to the development of pre-service teachers' student knowledge have been widely emphasized (Masingila & Doerr, 2002). The second one is the creation of an environment of discussion on the pre-service teachers' lesson plans and implemantations. In this environment of discussion, the pre-service teachers pondered and exchanged ideas about the students' ways of thinking. This can be seen as one of the factors triggering the change in the pre-service teachers' knowledge (Guskey, 2003). In light of the findings of the current study, it can be suggested that models such as lesson study should be integrated into teacher training programs to detect and overcome the shortcomings in pre-service teachers' student knowledge.

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