Pre-service teachers' reflections on task design and implementation

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In this paper, we will present a part of findings of a larger study that we investigated both pre-service teachers' pedagogical content knowledge and middle school students' mathematical skills. A total of 17 pre-service teachers worked with 7th grade students on the mathematical tasks for a semester. The data was collected through inventories, videos of task implementations and written reflections. The analysis of inventories and written reflections revealed that the pre-service teachers had positive beliefs about using mathematical tasks in the lessons. They were able to evaluate the success or failure of a task by analyzing the implementation process. They recognized the importance of preparing appropriate tasks for students and implemented them as intended. They also noted that mathematical tasks provide them an opportunity to learn about students' mathematical understanding as well as to develop their scaffolding practices.

Keywords: pre-service, middle school, mathematical tasks, reflection, teacher knowledge.

Introduction

The studies on mathematical tasks provide an opportunity to discuss not only students' mathematical thinking and understanding but also teachers' knowledge and skills (Zaslavsky, 2007). Tasks are accepted to be one of the curricular tools that help teachers to scaffold, foster and assess students' understanding when used appropriately (Stein, Grover, & Henningsen, 1996; Watson & Mason, 2007). Research on task design and implementation shows that "good" tasks or *cognitively demanding tasks* (Stein et al., 1996) have positive impacts on students' thinking and understanding (Henningsen & Stein, 2002). Such tasks encourage students to think about what mathematical concepts are conveyed in the task, what they know about them, how they are related to other concepts and which strategies, representations or materials are helpful in terms of arriving at a meaningful solution or answer. On the other hand, designing, selecting and implementing cognitively demanding tasks are related to teachers' pedagogical content knowledge (PCK) as well as to their content knowledge (Charalambous, 2010; Liljedahl, Chernoff, & Zazkis, 2007; Stylianides & Stylianides, 2008). Teachers' decisions about whether a task is appropriate for their students in terms of its complexity or if their students possess the necessary prior knowledge or the task's goal aligns with the lesson's objectives emerge from their PCK (Hill, Ball, & Schilling, 2008). The studies on task design and implementation showed that when pre-service teachers (PSTs) were given opportunities to develop and implement tasks, they were able to prepare "good" tasks in which they used real life context and multiple representations and they asked for explanation, interpretation or justification (Ozgen & Alkan, 2014).

In this study, we aimed to investigate how PSTs' involvement in task design and implementation process influenced their views about tasks and their PCK. We used tasks as a tool to build up an environment for PST-student and student-student interactions where the PSTs observed how

students worked on the tasks both individually and as a group and then joined their discussions to elicit students' thinking and support their understanding. Thus, the PSTs had opportunity to learn about students' mathematical skills and also to gain experience about how to implement a task without loss of fidelity, to scaffold students' understanding, and to manage the group work. In this paper, however, we will present some findings about PSTs' reflections on this task design and implementation process in terms of effectiveness of the tasks and their professional gains from this intervention study.

Methodology

Research setting

This study was conducted under university-school collaboration between the mathematics education department and a local middle school in Istanbul in Turkey. A total of 17 PSTs (10 of them in Fall 2015 and 7 of them in Spring 2016) and one of the 7th grade classes (aged between 12-13) from the partner school volunteered to participate in this study[1]. We arranged the students as mixed-ability groups of 4 students based on the results of an achievement test. We randomly assigned the PSTs to these groups. The PSTs worked with students in a 40-minute lesson for each week, a total of 11 weeks during the Fall and 12 weeks during the Spring.

All PSTs were senior students who volunteered to take an elective course that was carried out specifically for this study. During the first couple of weeks of the course, we talked about the design and implementation of tasks, effective ways of communicating with students and assessment of students' mathematical understanding through samples. Then, each week, prior to implementation, we discussed the tasks that they would work with the students and made revisions on the tasks when necessary. After each implementation in the school, we met the PSTs again and discussed how the implementation went. We wanted PSTs to write reflection on each implementation by analyzing the implementation videos of their own group and students' worksheets. We also asked PSTs to prepare and implement a set of tasks for their own group at the end of the semester.

The tasks

We prepared the tasks in alignment with the 7th grade mathematics curriculum. In the Fall semester we prepared 10 tasks which were about integers, fractions, rational numbers and algebra. In the Spring term we prepared 11 sets of tasks which were about geometry, algebra and data and statistics. Each set of tasks consisted of 3 to 4 sub-tasks with some additional problems. The tasks were set up around a common theme which related to the use of mathematics in daily life. For instance, in one of the data analysis tasks, we conducted a short survey on students' preferences in the class such that we gave them a list of foods where each student would choose 5 of the foods from the list. Then we wrote down the frequencies for each food on the board and then asked them to answer questions about their preferences such as finding out the most popular food, making a bar

[1] The school was located in a crowded neighborhood in terms of school-age children. There were 40 students in the class, average size according to national education statistics, but in the Spring semester 4 students dropped out. Since we had only 7 volunteers in the Spring semester, two researchers from the research team worked with two of the groups.

graph of the drinks, etc. The majority of the tasks that we used were selected from the ones that we implemented in the previous years. However, we revised those tasks before the implementation based on the needs and performances of the students in our new sample.

Data collection

The data was collected through pre and post questionnaires, videos of PSTs' task implementations and group discussions, and PSTs' written reflections and assignments. One of the questionnaires (Kayan, Haser, & Isiksal-Bostan, 2013) consisted of 26 5-point Likert-type items asking for PSTs' beliefs about mathematics and mathematics teaching. The other questionnaire was developed by the research team and it consisted of open-ended questions where in the pre questionnaire the PSTs were asked to write about their prior teaching experiences and their expectations from the study and in the post questionnaire they wrote about whether their expectations were met or not and what they had learned from this intervention, etc. In their written reflections, we wanted PSTs to discuss about how the implementation went. Among the other questions, we asked them to comment on whether the students were able to complete the tasks, whether the tasks achieved their goals or not and why, and what they would do as follow up. At the end of the semester, we wanted them to discuss in which tasks the students experienced the most difficulty and what their suggestions would be to revise those tasks. Furthermore, we asked them to prepare tasks for their own groups and provide the rationale behind those tasks.

Data analysis

We have not analyzed all data yet. However, because the knowledge of students' thinking and understanding, the ability of selecting or developing appropriate tasks, and using appropriate teaching strategies for particular group of students are counted in teachers' PCK (Hill et al., 2008), we are basically looking for any instances that could be counted as an influence of task design and implementation process on the PSTs' PCK and their views about tasks. For instance, whether they paid attention to the students' earlier performances while preparing their own tasks, how accurate assumptions they were able to make about students' performances on the new tasks, etc. Yet, we did document analysis such that we analyzed the items related to task design and implementation from the questionnaires, written reflections and assignments. We attempted to figure out the frequencies of common issues that emerged from those instruments. We found out the mean scores of the items in the Likert-type questionnaire but we did not compare pre and post results because of low number of participants. We examined pre and post open-ended questionnaires, the assignments asking for making overall evaluation of the study and the reflection reports including PSTs' reflections on the implementation of their own tasks. We developed a coding scheme for the common issues that emerged from the reflection reports. For instance, when discussing the reasoning behind the success of the tasks, if the PSTs wrote that "they liked it" or "they enjoyed it" or "they had fun with it" then we coded that reasoning as "enjoyable" (see Table 1). However, out of possible 194 reflection reports, 6 of them were missing. Therefore, we coded a total of 188 reports. We achieved 90% agreement in initial coding. We discussed the discrepancies by re-reading the PSTs' reports and then we came with an agreement. Moreover, we all agreed on the common issues that emerged from the open-ended questionnaire and the assignments.

Findings

PSTs' thoughts about use of tasks in mathematics

The analysis of items in the Likert-type questionnaire showed that the PSTs agreed that teachers should encourage students to be active learner (The average of 3 related items; pre $\bar{x} = 4.38$; post $\bar{x} = 4.45$), the tasks are important for students' learning and understanding (The average of 2 related items; pre $\bar{x} = 4.36$; post $\bar{x} = 4.61$) and manipulatives and materials facilitate students' understanding (The average of 3 related items; pre $\bar{x} = 4.09$; post $\bar{x} = 4.60$). Their answers in the open-ended questionnaires were compatible with these results. The PSTs noted that doing mathematics through tasks enables students to participate in the lesson ($f = 5$), love mathematics ($f = 4$), discover or review mathematical concepts or facts ($f = 4$), and use materials or manipulatives ($f = 4$).

PSTs' reflections on the implementation of the tasks

In the reflection reports, we asked the PSTs to comment on the following questions: 1a) Were the students able to complete the task? 1b) Did the task attain its goal or not? 1c) Why did the task attain its goal or not? 2) What more would you like to do about this implementation? 3) What is your suggestion for the follow up of the task? The PSTs gave various answers to these questions. For instance, for the question 1a they noted that some of the students completed the task or just one student could not finish all of them, etc. Although we coded them separately, we re-coded them in terms of whether their answers were most likely "Yes" or "No". Similarly, we defined 12 different answers for question 1c. However, we preferred to present only the most frequent ones. In Table 1, the frequencies of PSTs' answers to these questions are given.

Q1a: Were the students able to complete the task?

	No	**Yes**
Fall	30 (29%)	75 (71%)
Spring	15 (18%)	68 (82%)
Total	**45 (24%)**	**143 (76%)**

Q1b: Did the task attain its goal or not?

	No	**Yes**	**No Comment**
Fall	38 (36%)	67 (64%)	
Spring	15 (18%)	63 (76%)	5 (6%)
Total	**53 (28%)**	**130 (69%)**	**5 (3%)**

Q1c: Why did the task attain its goal or not?

	No Comment	**Enjoyable**	**Lack of Knowledge**	**Use of Materials**	**Recognize own Mistakes**
Fall	28 (27%)	10 (10%)	32 (30%)	11 (10%)	14 (13%)
Spring	19 (23%)	5 (6%)	19 (23%)	1 (1%)	14 (17%)
Total	**47 (25%)**	**15 (8%)**	**51 (27%)**	**12 (6%)**	**27 (14%)**

Q2: What more would you like to do about this implementation?

	No Comment	Nothing more	Discuss more	Teach for Understanding
Fall	9 (9%)	17 (16%)	37 (35%)	29 (28%)
Spring	1 (1%)	58 (70%)	15 (18%)	6 (7%)
Total	**10 (5%)**	**75 (40%)**	**52 (28%)**	**35 (19%)**

Q3: What is your suggestion for the follow up of the task?

	Nothing more	Review for Exercise	Review for Learning	Easier Tasks
Fall	5 (5%)	46 (44%)	31 (30%)	6 (6%)
Spring	16 (19%)	42 (51%)	12 (14%)	3 (4%)
Total	**21 (11%)**	**88 (47%)**	**43 (23%)**	**9 (5%)**

Table 1: The frequencies of pre-service teachers' answers to the questions about task implementation

As seen in the table, the PSTs noted that in a 40-minute lesson the students were able to complete the given tasks and discuss their answers (76%). However, some of the PSTs wrote that the tasks were difficult for their students and they only answered one of the sub-tasks. For some of the tasks, the PSTs noted that although the students completed the tasks, there was no time for themselves to discuss students' answers as a group discussion.

The PSTs wrote that some of the tasks did not attain their goals (28%) mainly because of lack of students' prior knowledge (27%). In a few cases, they noted that the students did not understand the task because the text was unclear (3%). Some of the PSTs attributed the success of the tasks to use of materials (6%) and context of the tasks that attracted students' attention (8%). Furthermore, some of the PSTs wrote that the tasks attained its goal because during the group discussion the students recognized their own mistakes and learned from each other (14%). However, in the 25% of the reports, the PSTs did not write anything about the reasoning behind the success or failure of the task. Furthermore, we analyzed the pattern in PSTs' perceived cause-and-effect relationship between Q1b and Q1c. Among the total of 141 responses to Q1c, the PSTs wrote that the tasks achieved their goals because students learned from each other while engaging in the task (f: 25), they used materials (f: 12) and they enjoyed it (f: 15). They noted that the tasks were not successful mostly because of students' lack of prior knowledge (f: 38).

As an answer to Q2, the PSTs noted that they were able to do whatever they wanted to do during the implementation (40%). However, some of them noted that there was not enough time to explore how students thought about the given tasks or they were unsure whether the students understood the reasoning behind the answers to the tasks or not, therefore they would like to discuss more about those issues (28%). In some of the cases, especially in the Fall term, because of students' lack of knowledge about fractions and rational numbers, the students could not finish the given tasks. In such cases, the PSTs wrote that they would like to teach about those concepts before or after the implementation if they had enough time (19%). On a total of 6% of the reports, the PSTs did not write relevant answers but summarized how the implementation went.

For the third question, 12% of the reports (not shown in the table) included irrelevant answers such as the PSTs suggested encouraging students to read more books to improve their reading skills or they criticized themselves in terms of not managing time better. In a few reports, they wrote that the

tasks were difficult for the students; there should be easier tasks on the same content domain (5%). However, they mostly suggested making review exercises for students to reinforce their understanding of the tasks as well as the content domain (47%). When they realized that the students did not know much about the content, they suggested remedial lessons for them (23%).

PSTs' reflections on the tasks and the intervention study

At the end of the semester, we asked the PSTs to evaluate this intervention study including the effectiveness of the tasks and the contributions to their own professional development. We specifically asked them to determine five mathematical issues in which students had experienced the most difficulty and two tasks that they would like to make revisions on them. We also asked them to give the reasoning behind the selection of those tasks and their revisions.

According to the PSTs, among the others, the students had difficulty in the tasks which were about fractions and rational numbers ($f = 16$), algebraic expressions ($f = 9$), solving equations ($f = 7$), area problems ($f = 7$), and discovering patterns ($f = 5$). They wrote that the students could not do these tasks completely because of their lack of prior knowledge ($f = 17$), lack of attention ($f = 7$), lack of review exercises done at home ($f = 5$), lack of understanding of the tasks ($f = 3$), and personal insecurity ($f = 2$). Specifically, they noted that students had difficulty in fractions, rational numbers and area problems because they did not know the algorithm for four operations with rational numbers as well as the area formulas of quadrilaterals and circle. They wrote that students failed in doing operations and discovering patterns because they did not make enough practice at home or did not pay attention to the operations and procedures. However, the tasks that they would like to make revisions were mostly about integers ($f = 7$), algebraic expressions ($f = 4$), fractions and rational numbers ($f = 3$), area problems ($f = 3$), and transformations ($f = 3$). The PSTs wanted to make revisions to the tasks about integers not because of students' lack of knowledge but because the context of the tasks was confusing for the students. Therefore, they noted that they would rephrase the text and change the order of the sub-tasks in those tasks. They decided to make the tasks about fractions and area problems easier because students did not possess the required knowledge to complete the tasks. Furthermore, in some cases the PSTs preferred to change the tasks that were done by the students but they were uncertain whether they understood them thoroughly or not.

The PSTs prepared a set of tasks for their own group of students at the end of the semester. Their rationale for their tasks was either to focus on the issues where the students experienced the most difficulty ($f = 13$) or to make an overall review of what was done during that semester ($f = 4$). In parallel to their comments about the students' mathematical difficulties, they prepared tasks about integers, fractions and rational numbers, area problems, algebraic expressions and solving equations. Some of the PSTs kept their tasks as simple as possible because of their students' poor performance on earlier tasks. Furthermore, 7 of the PSTs prepared their tasks around a common theme as we did in this study but 10 of them prepared separate problems related to the content domain that they focused on.

In the post open-ended questionnaire, the PSTs wrote that this intervention study contributed to their professional knowledge in several ways. Among the others, they noted that they practiced how

to scaffold students' understanding without directly telling them the solution or answer ($f = 7$), they got better in anticipating students' possible difficulties in mathematics ($f = 5$), they learned to be patient ($f = 4$), and they learned what kind of tasks attract students' attention more ($f = 3$).

Discussion

The findings of this study have potential to contribute to the relevant literature that teachers learn from their own task design and implementation practices in terms of better understanding of students' mathematical thinking and how to use or tailor tasks to scaffold students' understanding (Zaslavsky, 2007). Although we have not yet analyzed all data, we recognized that the PSTs were able to evaluate the task implementation process in terms of the facts related to the task itself, the organization, the students and their own professional development.

When we asked the PSTs to write their thoughts about the success or failure of the tasks, they were able to make reasonable inferences from the implementation. They recognized that the tasks were successful because the students were actively involved in the solution and discussion process (14%, see Table 1, Q1c), the materials were appropriate for the tasks (6%, see Table 1, Q1c), the tasks were aligned with the 7^{th} grade curriculum and they were in the role of facilitator of group discussion (28%, see Table 1, Q1c and results of post questionnaire). In only a few of the cases, they noted that the students failed to complete the task because the task was unclear for the students (3%). For the other cases, they did not blame the tasks but the students because they did not possess necessary prior knowledge that they learned in previous grade levels or in their regular mathematics lessons (27%, see Table 1, Q1c). The PSTs' interpretations revealed that they began to recognize students' mathematical understanding as well as the importance of preparing tasks both aligned with the curriculum and appropriate for a particular group of students (Hill et al., 2008). For instance, while preparing their tasks they did not prefer to use higher cognitive demand tasks but the easier ones because some of their students did not know about the procedures required to solve given tasks, such as the rules of four operations with rational numbers. The PSTs also commented that students should revise the issues discussed in their mathematics lessons in order to understand the mathematics conveyed in the tasks (47%, see Table 1, Q3). Moreover, as we inferred from their answers in the questionnaire they appreciated the facilitator role of the teacher during the task implementation. They stated that they suppressed their feelings of telling and teaching when students could not figure out the solutions. Briefly, their reflections on the tasks and the implementations indicated that they were aware of the task implementation process which begins with selection of appropriate tasks, continues with implementation of the tasks and ends with evaluation of students' learning (Stein et al., 1996). Because orchestration of task implementation process involved in teachers' PCK, such awareness of the PSTs can be counted as a sign of their PCK (Charalambous, 2010). However, because we have not yet analyzed the implementation videos, we are not able to validate PSTs' reflections on the tasks implementation process, especially whether they were able to implement the tasks without loss of fidelity and manage the group discussions appropriately. Indeed, it is hard for teachers, even more for PSTs, to keep the cognitive demand of the tasks such that they might have provided hints or helped students when the students did not possess the required knowledge (Stylianides & Stylianides, 2008). Therefore, we are not

able to comment on their "PCK in practice" even though we could make inferences about their PCK from their written reflections.

Finally, the analysis of pre and post questionnaires revealed that the PSTs had positive beliefs about use of student-centered teaching strategies, mathematical tasks and manipulatives while teaching mathematics and such beliefs sustained and even increased throughout the study. They recognized that tasks provided an opportunity for them to elicit students' mathematical understanding and they could be used as a tool to foster students' mathematical understanding.

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