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Preservice teachers' noticing of mathematical opportunities

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The aim of this study was to investigate the effects of a faculty-school collaboration program on preservice mathematics teachers' professional knowledge and skills. Seven preservice teachers worked with a group of students from the collaboration school such that they attempted to understand and support students' mathematics through the implementation of mathematical tasks. Video tapes and written documents were used to detect any changes in preservice teachers' noticing of mathematical opportunities emerged from students' mathematics. A coding scheme was developed to understand the pattern in their noticing skills. The results revealed that preservice teachers were able to attend to mathematical opportunities during the implementations as well as in oral and written reflections took place after implementations. Furthermore, they began to enrich their interpretations of students' mathematics by giving examples from students' work and their interactions with students.

Keywords: Noticing, preservice teachers, mathematical opportunities, faculty-school collaboration.

Introduction

For effective teaching, teachers should support students' mathematical understanding by organizing appropriate learning environment for students and giving various learning opportunities for students as well as providing necessary scaffolding for their learning (Ball, Thames, & Phelps, 2008). Teachers' such ability of eliciting and interpreting students' mathematics and scaffolding their understanding is a sign of both their *Mathematical Knowledge for Teaching* (MKT) (Ball et al., 2008; Stockero, Rupnow, & Pascoe, 2017) and also their noticing skills (Jacobs, Lamp, & Philipp, 2010; Schoenfeld, 2011; van Zoest et al., 2017). Because MKT involves in knowledge of how students learn and understand mathematics while noticing entails attending to learning opportunities occurred during instruction, interpreting students' thinking and taking an action for fostering students' understanding (Jacobs et al., 2010). In other words, MKT and noticing skills of teachers are interrelated (Stockero et al, 2017; van Zoest et al., 2017). Indeed, in-service teachers have opportunity to improve such knowledge and skills in schools throughout years such that they could enrich their repertoire of students' thinking styles, capabilities and needs in mathematics as well as teaching strategies that are appropriate for their students. However, recent studies on preservice teachers' training (PSTs) revealed that intervention studies conducted under teacher education programs were likely to support development of PSTs' MKT and noticing skills to some extent as well (e.g., Barnhart & van Es, 2015). In the light of such findings, we developed a faculty-school collaboration program for PSTs to investigate the nature and the development of their professional knowledge and noticing skills. As a requirement of the program, PSTs worked with a group of students on the mathematical tasks in a school setting throughout a year such that they videotaped all implementation sessions and then reflected on the implementations both orally and in written.

Theoretical framework

Noticing entails paying attention to important instances occurred in the classroom however it is difficult to decide what is noteworthy or not. In this study, we decided to focus on students' mathematical thinking and understanding and we used Leatham and his colleagues' (Leatham, Peterson, Stockero & van Zoest, 2015) definition of *Mathematically Significant Pedagogical Opportunity to Build on Student Thinking* (MOST) as a unit of analysis to investigate PSTs' noticing skills. They described MOST as a composition of three sequential components such that it should be emerged from student's mathematical thinking, be mathematically significant and be a pedagogical opportunity (see for details Leatham et al., 2015). For instance, finding the answer of $-8+5$ as -13 might be counted as a MOST if it occurs while teaching operations with integers. In this case, the student thinks that addition of a negative and a positive integer is utilized as addition of natural numbers such that the sign of the first number is omitted first but then it is attached to the result. Because such an answer is observed while teaching integers, it is both mathematically significant and also a pedagogical opportunity to be discussed at that time in the class. Leatham and his colleagues also noted that not only students' misconceptions or incomplete reasoning but also their correct answers based on use of different strategies or approaches, mathematical contradictions or "why" questions might be coded as a MOST instance.

We adopted Jacobs and her colleagues' (Jacobs et al., 2010) definition of *professional noticing of students' thinking* to analyze PSTs' noticing skills. They defined noticing as having three interrelated components as attending to students' strategies, interpreting their understanding and deciding how to respond to students' mathematics. In this study, we analyzed PSTs' noticing in terms of whether or not they attended to MOST instance, how explicitly and accurately they interpreted students' thinking or student mathematics and how they responded to the MOST instance. We attempted to investigate PSTs' noticing during implementations (in-the-moment) and after implementations (in oral and written reflections). The implementation videos provided data about *attending* and *responding* while written and oral reflections used for *attending* and *interpreting* components of noticing. Although we asked PSTs to comment on their responding actions in oral and written reflections we did not count them as responding component but as a sign of interpretation of student mathematics as well as an indicator of their MKT.

Methodology

Research setting and participants

This study was conducted under a university-school collaboration program between a large university in Turkey and a local middle school in the neighborhood of the university. In the line of the collaboration, we took the responsibility of administration of an elective mathematics course offered for the seventh grade students in the school such that we grouped students and assigned a volunteer PST to work with these students on the mathematical tasks.

Seven preservice teachers attended to the program both in fall and spring semesters. Four of them were sophomore (Asya, Aydan, Ayla, Aysun) and three of them were junior (Bahar, Berna, Beste) undergraduate students of mathematics education program.

At the beginning of fall semester, a couple of weeks, we discussed about design and implementation of mathematical tasks as well as students' common misconceptions, and effective ways of understanding and supporting students' mathematical thinking. We discussed these issues via some sample videos and student work that we had in our repertoire from our earlier studies. Then we assigned a group of four students for each PST that they would work with in the school for a year. Each group consisted of mixed ability students in terms of mathematics achievement.

We followed a 4-step intervention process for PSTs: pre-implementation discussion, task implementation, post-implementation discussion and written reflection. During pre-discussions we talked about the students' possible performance on the tasks as well as any modifications in the tasks before the implementation. Then, PSTs implemented the tasks in the school such that they allowed students worked on the tasks individually at first and then students discussed their answers as a group and finally PSTs began to interact with students to address mathematical opportunities occurred during the implementations. During post-discussions, each PST talked about how students performed on the tasks and how they addressed to students' mistakes or misconceptions. Each of these discussion sessions and implementations were videotaped. Then we asked PSTs to write reflection reports based on their videos and students' worksheets.

As the research team, we prepared 20 tasks such that 5 of them were about numbers, 7 of them were algebra, 5 of them were geometry and 3 of them were data and statistics. We also asked PSTs to prepare at least one task for each content area for their own groups and implement them. We used 2 lesson hours (80 min.) for each task implementation and we spent a total of 25 weeks in the school.

Data collection and analysis

We used discussion and task implementation videos, and PSTs' written reflections as the main source for PSTs' noticing skills. Furthermore, we used task implementation videos and students' worksheets to identify MOST instances. We determined MOST instances according to Leatham and his colleagues' (2015) framework. Based on Jacobs and her colleagues' (2010) definition of noticing we developed a coding scheme to identify PSTs' noticing skills in terms of attending to MOST, interpreting student mathematics and responding to students. While developing the coding framework we used similar frameworks in the literature (e.g., van Es, 2011) and also made a workshop with math educators to get their suggestions. The scheme that we used for coding is presented in Table 1.

In the moment (Interaction)	Attending	0	Missed the MOST	
		1	Attended to the MOST	
	Answer-focused			
	Responding	0	<i>(No attempt)</i> Only tells to the students that their answers/solutions are wrong; no guidance for students	
		1	<i>(Explanation)</i> S/he or other students tells/explains the procedure or solution	
		2	<i>(Orientation)</i> Attempts to make students find out the correct answer through short-answer, Yes/No type, prompting (directs students to correct answer like "...,isn't it?"), no-follow up, non-specific type of questions or b) asking them to re-read, re-do, re-think	

		Mathematical understanding-focused	
		3	<i>(Exploration)</i> Attempts to elicit students' thinking by asking probing questions (why, how, what if, ...) but either conversation is not concluded or in case of existence of misconceptions /misunderstandings she fails to address the gap in student's mind because her guidance involves partially incorrect issues such as lack of terminology, inappropriate examples or representations
		4	<i>(Elaboration)</i> Attempts to elicit students' thinking by asking probing questions and guiding students through appropriate examples, representations, connections between concepts and representations
Oral reflection	Attending	0	Missed the MOST
		1	Attended to the MOST
	Interpreting	0	No interpretation
		1	Non-specific about student mathematics
	2	Specifically mentioned about student mathematics	
Written reflection	Attending	0	Missed the MOST
		IR	Attended to the MOST both during Interaction and in Report
		I	Attended to the MOST only during Interaction
		R	Attended to the MOST in Report
	Interpreting	0	Does not provide any interpretation or states that she did not understand what the student did/thought about
		1	Just rephrases students' written procedures and/or points out students' mistakes
		2	Comments on the possible reasoning behind student mathematics but provides limited justification such as blaming student for lack of knowledge or her comments about student mathematics is partially correct
		3	Comments on the possible reasoning behind student mathematics by providing examples from students' work or vignettes from student-teacher interaction but do not explain the justifications explicitly
		4	Gives a detailed explanation about possible reasoning behind student mathematics by providing valid justifications

Table 1: Framework for teachers' noticing skills

We used different identifiers and levels for interpreting component of written and oral reflections because during oral reflections we gave a limited time for PSTs to talk however, they had enough time to write about implementation and students' performances. Furthermore, as the research team we discussed all MOST instances and codes for PSTs' noticing skills together. Thus, we have achieved a consistency in coding of each PSTs' noticing and MOST instances, in other words, we fully achieved interrater reliability.

Findings

In this paper, we present the data collected from seven PSTs who attended to the program in both semesters. A total of 354 MOST instances (approximately two MOST instances per week for each PST) were detected throughout the year. Although Leatham et al. (2015) discussed various sources of MOST instances, including students' alternative solutions or their answers for "why" questions, in this study majority of MOSTs emerged from students' misconceptions. Furthermore, because we

mentioned about students' possible misconceptions during pre-implementation discussions, PSTs were somewhat familiar to such instances before the implementations. Indeed, 45% of MOST instances were already mentioned in the pre-implementation discussions while 55% of them were new for the PSTs. The frequency distribution of how PSTs attended to those MOST instances is presented in Table 2.

		Interaction							Oral Reflection					Written Report								
		Attending		Responding					Attending		Interpreting			Attending				Interpreting				
		0	1	0	1	2	3	4	0	1	0	1	2	0	I	R	IR	0	1	2	3	4
Asya	Fall	3	18	1	10	6	1	0	6	15	6	1	14	1	5	2	13	0	6	3	3	3
	Spring	5	24	0	13	7	2	2	6	23	6	0	23	2	2	3	22	0	5	14	2	4
Aydan	Fall	8	11	2	6	3	0	0	6	13	6	7	6	4	5	4	6	0	3	2	0	5
	Spring	3	24	0	17	5	2	0	3	24	3	3	21	0	3	3	21	0	4	8	6	6
Ayla	Fall	2	19	0	10	9	0	0	6	15	6	4	11	0	2	2	17	0	4	6	5	4
	Spring	3	25	0	7	12	5	1	4	24	4	2	22	0	0	3	25	0	5	7	6	10
Aysun	Fall	3	18	0	14	4	0	0	5	16	5	7	9	1	1	2	17	0	7	7	1	4
	Spring	4	22	0	15	7	0	0	8	18	8	2	16	0	0	4	22	0	4	10	3	9
Bahar	Fall	0	25	3	12	8	1	1	7	18	7	3	15	0	5	0	20	0	16	3	1	0
	Spring	3	26	1	11	10	4	0	5	24	5	4	20	3	2	0	24	0	10	7	6	1
Berna	Fall	2	21	1	11	9	0	0	8	15	8	3	12	2	4	0	17	0	7	6	2	2
	Spring	2	25	0	18	6	0	1	6	20	6	9	11	2	3	0	22	0	7	9	4	2
Beste	Fall	0	25	5	7	12	1	0	11	11	11	3	8	0	5	0	20	0	9	7	4	0
	Spring	1	32	2	17	11	1	1	6	27	6	3	24	1	8	0	24	0	8	12	4	0
Total	Fall	18	137	12	70	51	3	1	49	103	49	28	75	8	27	10	110	0	52	34	16	18
	Spring	21	178	3	98	58	14	5	38	160	38	23	137	8	18	13	160	0	43	67	31	32
		11%	89%	2%	55%	33%	8%	3%	19%	81%	19%	12%	69%	4%	9%	7%	80%	0%	25%	39%	18%	18%

Table 2: Coding of preservice teachers' noticing skills

When we analyzed data about noticing during implementations, we observed that the PSTs attended to majority of MOST instances in both fall and spring semesters (88% and 89%, respectively). In terms of responding to MOST instances, it was observed that PSTs attempted to guide students in some ways (totally 91% in Fall and 98% in Spring) but they mostly preferred answered-focused actions in both semesters (totally 88% for each semester). However, it was seen that in the spring semester they attempted to elicit students' mathematics in the form of *exploration* and *elaboration* more in comparison to fall semester (totally 3% in Fall, 11% in Spring).

In terms of written and oral reflections after implementations it was also observed that PSTs attended to MOST instances occurred during implementations. During post-implementation discussions the instructors from the research team asked about how implementation went and what PSTs observed about students' mathematical performances. When discussion videos were analyzed it was observed that PSTs mentioned about the MOST instances occurred during the implementations (68% in Fall and 81% in Spring). Furthermore, they attempted to give justifications for students' performances such that the percentage of such specific comments about students' mathematics increased in spring semester (50% in Fall, 69% in Spring).

The PSTs attended to some of the MOST instances that they missed during the implementations in their written reports such that in total they attend to 10 of the 18 missed MOSTs in fall (approx. 56%) and 13 of the 21 missed MOSTs in spring (approx. 62%). However, there were cases that PSTs did not write about the MOST instances even though they attended to them during the interactions. When we compared the semesters, the number of such cases decreased in spring semester from 17% to 9% as seen in Table 2. That is, PSTs attended to MOST instances in both during interaction with students and in their written reports (71% in Fall and 80% in Spring). We also analyzed how PSTs interpreted student mathematics in their written reports. It was observed that all PSTs attempted to interpret students' mathematical thinking behind the MOST instances. Although in fall semester the percentage of the cases that PSTs only wrote about what students did (Level 1 in coding scheme) was high, it decreased in the spring semester (43% in Fall, 25% in Spring). That is, they began to comment on students' mathematics by providing justifications from their interactions with students and students' written work (totally 56% in Fall and 75% in Spring).

We also analyzed how each PST's noticing varied in fall and spring semesters. As shown in Table 3, we analyzed their responding actions during interactions in terms of answer-focused vs mathematical-understanding focused. We also categorized their interpretation of students' mathematics in terms of providing justifications or not. As seen Table 3, Aydan showed a progress in terms of attending to MOST instances in the moment of implementations. In terms of responding actions, except Aysun, PSTs attempted to elicit or elaborate students' mathematical understanding during the interactions such that there were more instances coded as "3" or "4" in spring semester. The PSTs also attended to MOST instances and specifically mentioned about students' mathematics during oral reflections. This fact was more evident in Asya's, Aydan's and Ayla's cases as shown in Table 3. Although all PSTs attempted to provide justifications for their interpretations of students' thinking in their reports, the change in Aysun's and Bahar's written reflections during spring semester was noteworthy. For instance, in fall semester Bahar was just writing about what students

did or she blamed students having lack of knowledge however in spring semester she began to explain the reasoning behind students' mathematics by providing examples from student work or sample vignettes of group discussions.

		Interaction			Oral reflection			Written reflection		
		Att.	Res.		Att.	Int.		Att.	Int.	
		1	0--2	3--4	1	0--1	2	IR	0--2	3--4
Asya	Fall	86%	95%	5%	71%	33%	67%	62%	60%	40%
	Spring	83%	83%	17%	79%	21%	79%	76%	76%	24%
Aydan	Fall	58%	100%	0%	68%	68%	32%	32%	50%	50%
	Spring	89%	92%	8%	89%	22%	78%	78%	50%	50%
Ayla	Fall	90%	100%	0%	71%	48%	52%	81%	53%	47%
	Spring	89%	76%	24%	86%	21%	79%	89%	43%	57%
Aysun	Fall	86%	100%	0%	76%	57%	43%	81%	74%	26%
	Spring	85%	100%	0%	69%	38%	62%	85%	53%	47%
Bahar	Fall	100%	92%	8%	72%	40%	60%	80%	95%	5%
	Spring	90%	85%	15%	83%	31%	69%	83%	71%	29%
Berna	Fall	91%	100%	0%	65%	48%	52%	74%	76%	24%
	Spring	93%	96%	4%	77%	58%	42%	81%	73%	27%
Beste	Fall	100%	96%	4%	50%	64%	36%	80%	80%	20%
	Spring	97%	94%	6%	82%	27%	73%	73%	83%	17%

Note: Att.: Attending, Res.: Responding, Int.: Interpreting

Table 3: Variations in preservice teachers' noticing skills

Discussion

In this study, we attempted to create an opportunity for PSTs to investigate nature and development of their in-the-moment noticing skills as well as noticing based on analysis of their own videos. As aligned with the findings of intervention studies mentioned in the literature (Barnhart & van Es, 2015; Stockero et al., 2017) this faculty-school collaboration contributed to PSTs' noticing. Firstly, PSTs were able to attend majority of MOST instances occurred during implementations. Pre and post implementation discussions might help PSTs to recognize the MOST instances because we talked about students' possible misconceptions and difficulties as well as how to eliminate such misconceptions during the discussions. Furthermore, as they got to know their students they got better in predicting their students' performances so that they had prepared for MOST instances which were likely to occur during implementations. This fact could be thought as an improvement in their MKT specifically in their specialized content knowledge and knowledge of students and content. Secondly, we observed changes in PSTs' responding actions throughout the year such that almost all PSTs achieved a transition from "No attempt" to "Elaboration" type of responding. However, such transition was not in progressive fashion (Barnhart & van Es, 2015) most probably because variations in students' prior knowledge and the context of the tasks (Kilic, Dogan, Tun, & Arabaci, 2018). For further studies, PSTs might be trained more for eliciting and elaborating type of responding actions before implementations of the tasks with students. Thirdly, analysis of own

videos supported PSTs' noticing skills (Barnhart & van Es, 2015; Stockero et al., 2017) such that they were able to recognize and wrote about the MOST instances that they missed during interactions in their reflections. Furthermore, written reflections provided an evidence for how PSTs interpreted students' thinking which was implicit in implementation videos.

Briefly, in addition to their theoretical courses, teacher educators should provide hands-on experiences for PSTs to promote their professional knowledge and skills. Although analysis of own teaching videos contributed to PSTs' noticing skills, for in-the-moment noticing, they should be given opportunities to work with students or teach in a classroom for a long period of time.

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