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A novice high school teacher's perception on the effect of content course taken as preservice

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The purpose of the current study is to provide findings of a follow-up study on a content course developed to improve specialized content knowledge of high school teachers. Elif was chosen to be interviewed among the participants of the content course according to certain criteria of sampling. Elif graduated within a year of taking the course and have been teaching in high school since. The individual semi-structured interview on her perceptions of how the content course influenced her teaching was conducted. The interview was transcribed and coded. Two themes emerged about the influence of the content course; using same examples or proofs, readiness to implement tasks for teaching. The findings show the participant's self-report of how she transformed her SCK experiences from university to her instruction. Furthermore, her answers revealed the relationship between SCK and PCK, how this unique knowledge of mathematics (SCK) forming basis for PCK.

Keywords: Specialized content knowledge, mathematical knowledge for teaching, novice teachers, content course, secondary mathematics teaching.

Introduction

Teacher knowledge has been in central position for teacher quality. Not only Shulman's (1986) work and emphasis on pedagogical content knowledge (PCK) but also further studies (e.g. Ball and her colleagues) on understanding nature of knowledge needed for effective mathematics teaching have been shedding light on role of teacher knowledge. In addition to studies to develop different models on teacher knowledge, there are many researches on understanding or improving teacher knowledge. However, most of those studies investigate either preservice teacher education (content or pedagogy courses) or in-service teachers (professional development). In this study the authors will share findings from a case study of a novice secondary school mathematics teacher's perception on influence of taking a content course focusing on Specialized Content Knowledge (Aslan-Tutak and Ertas, 2013) on her teaching. Authors will shortly review literature on mathematics teacher knowledge that guides this research.

Mathematical Knowledge for Teaching

The theoretical framework of this study is mathematical knowledge for teaching (MKT) model developed by Ball et al. (2008). According to MKT model, there are six sub-domains of teachers' knowledge for mathematics teaching. Three sub-domains of subject matter knowledge are Common Content Knowledge, Specialized Content Knowledge, Horizon Content Knowledge, and sub-domains of pedagogical content knowledge are Knowledge of Content and Students, Knowledge of Content and Teaching Curriculum Knowledge. Since this model is very well known, in literature review part of this paper, authors will focus on only Specialized Content Knowledge (SCK). Further information about these domains can be read from Ball et al. (2008).

SCK is a type of subject matter knowledge; it is defined as mathematics knowledge which is unique to teaching. Indeed, it is about knowledge about mathematics, not teaching, but for teaching. Ball and her colleagues stated the role of SCK as follows:

What caught us by surprise, however, was how much special mathematical knowledge was required, even in many everyday tasks of teaching— assigning student work, listening to student talk, grading or commenting on student work. Despite the fact that these tasks are done with and for students, close analysis revealed how intensively mathematical the tasks were. (Ball et al., 2008, p.398)

Due to nature of SCK it may be omitted in university mathematics courses and also in pedagogy courses (Ball, et al., 2008). Especially in secondary school teacher education, mathematics courses are advanced and require teachers to study mathematics from a different perspective than teaching. Since MKT model was developed based on a study of elementary school teachers, it was necessary to revise definition of SCK for high school preservice teachers. In an attempt to improve high school preservice mathematics teachers the first author developed a mathematics content course. The course content was developed by addressing not only MKT but also Advanced Mathematical Knowledge model of Zaskis and Leikin (2010), Advanced Mathematics for Secondary School Mathematics Teachers by Usiskin and his colleagues (2003), and SCK task development perspective of Suzuka and her colleagues (2009). Usiskin and his colleagues emphasized three types of mathematics experiences for secondary school mathematics teachers; concept analysis, problem analysis and mathematical connections. Lastly, the content course practices were developed to allow preservice teachers to unpack their already existing knowledge and to develop a flexible understanding of concepts (Suzuka et al., 2009). How these models and perspectives were merged together to form a content course can be read in detail in author's previous paper for CERME 8 (Aslan-Tutak & Ertas, 2013).

Since our research is a follow up study, it is needed to mention about aforesaid content course's ingredients. The mathematical tasks which were used during the course can be categorized under four approaches; unpacking concept definitions, applications and modeling, procedures and generalizations, and historical perspective of concepts (Aslan-Tutak & Ertas, 2013).

Unpacking concept definitions practice was identified by participants as eye-opening experience. One example is the activity focusing on geometric definition of imaginary number " i ". Almost all of the students stated that they had seen geometric representation of " i " for the first time and they were really surprised. The instruction which focused on geometric representation of " i " was discussed in Aslan-Tutak and Ertas (2013) as;

In order to explore number " i ", instruction started with discussion on the roots of an equation as its constant terms changes (Usiskin, et al., 2003). Then graphs of the equations were plotted on Cartesian plane (geometric representation of the equations) and their roots showed on a number line (geometric representation of real numbers). The number line was sufficient for the roots of first two equations but participants realized that they could not show the roots of third equation on number line. Then, the definition of the imaginary number i was discussed by rotation of 90° perspective (Lakoff & Núñez, 2000; Trudgian, 2009; and Usiskin et al., 2003) which provides a geometrical understanding of the imaginary number.

Second categorization of the course was applications and modeling. In the content course, there were some modeling problems for the topic of functions and also alternative definition of function. An example of modeling activity was about oil spill and its cleaning procedures. At the beginning of the problem there were some discussion about oil spill incidents in Gulf of Mexico and France and its effect on environment. After discussion part, the students were taken the problem as: *If there was 8000 gallon oil due to a spill, and the crew can clean only 80% of oil for a week. So how much oil would remain after a week? And how long will it take to clean until there is 10 gallon of oil is left?* Erbas et al. (2014) discussed two approaches in use of modeling: as a means of teaching mathematics and modeling as an aim of teaching mathematics. In this current study, the authors used modeling in content course as a means of teaching mathematics. This practice was aimed to introduce preservice teachers to use mathematical modeling in instruction while examining definition of functions. In addition to modeling, history of mathematics was used for examining functions. For example, history of logarithm and Napier's problem were studied. The historical approach was not limited to functions but almost all the topics, such as history of irrational numbers.

Participants of the content course stated that, the proof of equality $0,9999\dots=1$ was also one of the surprising tasks of the course. Seven different approaches to show it were posed to preservice teachers and then the relationship between the aforesaid proof and converting infinitely repeating decimals to fraction without any formula were established. This mathematical task was used with preservice teachers in different settings. Conner (2013) used this task to promote argumentation with preservice teachers. She stated that "Engaging prospective secondary teachers in mathematical argumentation is important so that they can learn to engage their own students in creating and critiquing arguments." (p. 172).

The second author of this current paper was a student at the time of the study. He graduated from the program and has been teaching for three years. The purpose of the content course was to improve participants' SCK which can be used during teaching. Therefore, the authors examined perceptions of participants, actively teaching in high schools, about how their learning from the undergraduate course transferred into their teaching.

Methods

The two-year long study, SCK development of high school teachers, was conducted at a mid-size, western public university in Turkey. The content course was offered in 2011 fall semester and 2012 fall semester. Based on students scores on national central university entrance exam, this high school mathematics teaching program had the highest rank among all of the mathematics education programs in Turkey. Students of this program had to take advanced level mathematics courses such as calculus, linear algebra, and complex analysis. Seventy percent of the courses are mathematics courses. Pre-service teachers also took general pedagogy courses, mathematics teaching courses and school practicum courses. At the time of this SCK project, there was no content course in mathematics teacher education program. The content course that developed based on this project was therefore elective for students. There were 31 students who enrolled to this course in 2012 fall semester.

The sample of the current study was determined based on three criteria; graduation from the program and starting teaching in spring 2013, teaching in high school, and living in Istanbul. Some of the students did not pursue career in teaching but other professions such as economics. Also, not all

students graduated in 2013. This condition was necessary in order to allow minimum time between taking the course and starting teaching. The second condition of teaching in high school was used because the topics of the content course were high school topics. The topics of this course are not covered in middle school. In order to investigate how novice teachers' transfer their SCK learning into their practices, it was important to choose participants according to grade levels they teach. The last condition of living in Istanbul was for convenience, in order to be able to conduct interview easily. There are some novice teachers who fulfill the first two conditions but they were living in other cities. Considering all of these conditions, there are only two novice teachers. Since one of them is the second author of this paper, the only other novice teacher (Elif, pseudonym name) was the sample for this study.

Indeed, all these conditions are also helping researchers to establish trustworthiness of the study. The conditions allow clear examination of transferability of the study. The findings of the study can be transferred into settings where preservice teachers study mathematics content for SCK in context of teaching and start teaching afterwards. Furthermore, in order to improve trustworthiness of the study researchers did member-checking with the participant. In addition to asking Elif to confirm interviewer's interpretations during the interview, later researchers also contacted her to discuss about findings of this case study. The member-checking also aided for the conformability of the study. For conformability, after the completion of analysis done by the first author, the second author went through the analysis. After this two-stage of analysis, Elif's member-checking was helpful to finalize findings. Elif approved most of the findings and she improved what we called "completeness". This phenomenon of "completeness" is discussed in findings section.

Yin (2013) explained the rationale of using case study research methodology as explaining "how" or "why" questions in-dept. The purpose of this study is to investigate how a novice high school mathematics teacher uses her SCK experiences in the content course. How does this course influence her teaching practices? Since teaching is a complex practice, it was necessary to examine this research question through case study methodology. The authors conducted a semi-structured interview with the participant, Elif. The interview questions were in two parts (i) background questions (e.g. years of teaching), (ii) her experiences in the course as a student and how these experiences influence her teaching.

Elif's interview was first transcribed and the open-coded. After open-coding, Elif's answers on how the SCK tasks in the course influenced her teaching practice were emerged into two themes; (i) using same example, proof in the classroom, (ii) readiness for implementing tasks of teaching (understanding student misconceptions, answering student questions, material development).

Findings

The first part of the interview was to understand Elif's teaching experiences and the environment that she has been working in. The school environment and possible mentor-mentee relationship is important in novice teachers development of practice. Elif took the content course in fall 2012 and graduated from university on June 2013. Right after her graduation, she started to work at a private high school, Baris Schools. Baris Schools is a school of a foundation which has more than 100 years background in education. Baris Schools have three K-12 campuses in Istanbul. In other words, Elif started to work at a well established school, a good opportunity for a novice teacher. After her first

year, she transferred to another campus and has been teaching for two years at that campus. So, she has been teaching high school (9-12 grades) for three years. In the interview, she stated that her school is a good place to learn about teaching. Considering how she transferred what she learned in content course in her teaching, she stated that mathematical exploration in the course provided her “completeness” for the topics/concepts that were covered in the course.

Elif: You can guide, direct the students to understand concept because you know that concept.

Interviewer: How do you direct them?

Elif: You construct the concept together, like i square to be -1 , by asking questions, when you are complete for content.

Especially as a novice teacher, she valued this feeling of completeness both when preparing instructional material and during the instruction.

Elif: When teaching, for the concept, you can be prepared. Your explanations are complete, select materials and put them in order.

According to Elif, completeness is a broad term which includes readiness to unexpected questions, constructing relationships between mathematical concepts and having deep understanding of the concepts. Her answers on how she transferred what she learned in the course to her teaching practice will be discussed in detail according to two themes that were emerged from data.

Using same examples or proofs

She stated that she kept all of the course materials, book, notebook, activities and presentations. She said, for some topics, she specifically used same examples. Her answers on what she kept same for her teaching reveal that she used alternative definitions (number i , mathematical functions), proofs (irrationality of $\sqrt{2}$, quadratic formula), and examples given for concepts (examples for exponential functions). For example, she had been teaching complex numbers for two years, she stated that she always introduced number i by the same geometric definition from the content course. But she made a differentiation about using materials from the course. Elif stated that while she was teaching geometric definition of number i for whole class instruction, she used many proofs only when certain group of students asked for further mathematical knowledge. She said that she decided to use a definition/proof/example based on students’ mathematics level. In the following quote from the interview, she described how she used “deriving the quadratic formula” that she learned in the content course.

Elif: When I explain it (quadratic formula) to students, even the order of doing it was stuck in my mind because we teach it this way, we give formula at the end. Before that to make square formula...It make sense, you get quadratic formula from making square formula. Discussing $b^2 - 4ac$ from the beginning, why there are two roots, or one root...Yes, it’s a terrible formula but we derive it together, of course with the ones who are good at math

Readiness to implement tasks of teaching

Content course, in other words SCK tasks that were done in the content course, aided Elif's teaching during the instruction when answering student answers. In the individual interview, Elif discussed about using her mathematical experiences from the content course. Many of Elif's answers to interview questions were emerged to form the theme, readiness for teaching. However, her answers were similar to mathematical tasks for teaching addressed in MKT model (Ball et al., 2008). So, in order to put emphasize on Elif's differentiation of demands of teaching, we merged her answers together and named them *readiness for implementing tasks for teaching*. As it was stated before in her feeling of completeness, she emphasized *knowing what to prioritize in teaching a concept*. She explained knowing and realizing the big idea in concepts several times. For example, while she was getting ready for teaching a concept, she knew what to emphasize in instruction even before thinking about how to teach it.

Elif: In complex numbers, maybe students didn't get why square of i is -1 , but I checked my notes (from content course) in order to get 180 degree rotation thing in my mind so I can teach it. This was for me actually.

The second code is *building awareness*, and directing her to find other resources. Elif didn't have to use same examples from course in her instruction. Mathematical tasks provided some awareness to her and she did further research about certain concepts. She stated that based on mathematical tasks in the course, she searched and found other tasks/examples from Khan Academy or YouTube. The third code is *directing students to understand concepts*. Elif emphasized the role of mathematics that she learned in course to help her ask mathematical questions to guide student thinking. In a sense, this is related to first code, identifying and knowing big idea of a concept. Further to that identifying big ideas, in this code, she is using that knowledge for directing student thinking.

Elif: In the class, maybe I didn't use exactly same example but when there is a student question, if it is related to mathematical concept, I can just direct student to reach the concept. Because I learned that content.

The fourth code under readiness to implement tasks of teaching is *answering student questions and addressing their misconceptions*. This code is related to previous one but Elif made explicit differentiation between directing students and answering students' questions.

Elif: When someone asks, or what does quadratic formula mean, why do we need it. I know these. When there is a question like these I can answer them easily.

Here, Elif focuses on her state of being confident in her mathematics knowledge when answering student questions. The last code, fifth one is related to her *implementation of curriculum*. As a novice teacher Elif stated using textbooks and course materials from other experienced teachers. However, she realized differences between her and experienced teachers in terms of implementing curriculum. In her first year, the national curriculum was revised extensively. One of the changes was how functions were introduced in 9th grade. In previous curriculum, first mathematical relations were introduced and then set theory approach of functions was given. In revised curriculum, functions should be taught through mathematical modeling without an introduction with mathematical relations. The covariation definition gains importance in this new curriculum. Elif realized that knowing alternative definitions of function (including covariation) helped her to easily adapt her

instruction to new curriculum. The SCK experiences of the content course provided basis for her use of the new curriculum. Furthermore, she was able to implement certain features of the curriculum while experienced teachers omitted.

Elif: Maybe, they don't think it (proof of $\sqrt{2}$ irrationality) is important. Because other teachers also analyzed the new book, but I said we need to do this. They didn't want to spent time on it. This actually give information about what do we need to give importance conceptually.

Discussion

The purpose of this study was to investigate perception of novice teachers on how they transfer what they had learned in the content course into their practices. Elif, a former student of this course and with 3 years of teaching experince, was volunteer to participate this follow up study. She stated that the course and mathematical explorations (SCK tasks) clearly helped her in teaching. The most expected influence would be using mathematics examples, tasks from the course. Usiskin and his colleagues (2003) discussed that "Often the more mathematics courses a teacher takes, the wider the gap between the mathematics the teacher studies and the mathematics the teacher teaches" (p. 86). So, based on findings from Elif's case study, it should be explored further if a content course with SCK tasks provides mathematical explorations that preservice teachers will be teaching in their profession. Furthermore, these SCK tasks also allowed Elif to unpack her knowledge of mathematics (Suzuka et al., 2009) so she could identify mathematical big ideas and prioritize important concepts.

It is important to note Elif's feeling of readiness in her first three years of teaching. There are various demanding tasks of mathematics teaching such as selecting appropriate mathematical task, using proper representations, answering student questions, and leading student discussions. Elif mentioned five different tasks (themes emerged from data analysis) of teaching that influenced by her experiences in the content course. Her discussion of these tasks may be used to depict how SCK is taking role in classroom instruction. It can be used to discuss the link between SCK and PCK. For example, when Elif discussed role of knowing mathematics in directing students to understand concepts, she was actually talking about PCK. She explained and clearly discusses the role of specialized knowledge of a teacher. Without this type of mathematics knowledge, she will be lacking directing students. Similarly, in using curriculum materials, she uses her SCK knowledge.

There are some limitations of this study such as sampling only novice teachers in Istanbul, and also relying on participant's self report on how she transferred what she learned in the content course. Even though, interview questions were specifically asking about the content course, there is still a limitation of influence of all other teacher education courses/practices on Elif's transfer from university to her teaching. Furthermore, Elif also has been teaching at a prestigious high school which provides various resources for a novice teacher to improve herself. In order to investigate further how preservice mathematics teachers transfer what they have learned into their teaching, researchers are planning to extend the study to include other participants who possess different characteristics.

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