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An Investigation on How Prospective Mathematics Teachers Design a Lesson Plan

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One of the components of pedagogical content knowledge is the knowledge required for designing a mathematics lesson. To obtain an effective teaching, it is necessary to prepare mathematics lesson plan. Lesson plans help teachers to document their ideas on teaching and share and/or use them after being adjusted according to students and teaching environment for upcoming years. The aim of this study is to investigate how prospective secondary mathematics teachers design lesson plans by using their pedagogical content knowledge. We have conducted this qualitative study with 60 prospective secondary mathematics teachers studying a five-year teacher education program at the Secondary Science and Mathematics Education department of a state university in Turkey. We have analyzed the lesson plans that are prepared by prospective secondary mathematics teachers in Teaching Methods course. The findings suggest that the prospective teachers preferred to use student-centered and technology-based teaching activities while designing their lesson plans. Prospective teachers also took into consideration the students' understandings and prior knowledge in the process of designing lesson plans. We have found out that the prospective teachers experienced difficulties since their mathematical content knowledge is not in comply with the conceptions included in the curriculum.

Key Words: Prospective mathematics teachers, Lesson plan, Pedagogical content knowledge, Teacher education

INTRODUCTION

There are various elements that may influence the effectiveness of teaching including understanding and having knowledge on (i) mathematics, (ii) students and, (iii) pedagogical strategies (NCTM, 2000). The content knowledge on its own is not adequate for teaching mathematics in an effective manner; examining the pedagogical strategies also plays a significant role (Ball, Hill, & Bass, 2005; Shulman, 1986). The prospective mathematics teachers could gain their pedagogical strategies during their teacher education program and their experiences in working with students. The prospective mathematics teachers' school experiences in the past both at K-12 and undergraduate level could often affect their perspectives on teaching mathematics (Barkatsas & Malone, 2005). Especially, teacher training programs enable teachers to obtain new perspectives towards mathematical content and teaching mathematics (Prescott, Bausch, & Bruder, 2013). The theory of teaching knowledge in the teacher training programs consists of subject matter knowledge, general pedagogical knowledge, and pedagogical content knowledge which is defined by Shulman (1987) as "a special amalgam of content and pedagogy that is uniquely the province of teachers, their own special form of professional

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understanding” (p. 8). Shulman’s theory (1987) contributed to teaching and learning mathematics significantly (Hill, Ball, & Schilling, 2008a). Pedagogical content knowledge investigates how to teach mathematical content and understand students’ way of thinking (An, Kulm, & Wu, 2004). Shulman’s (1986, 1987) pedagogical content knowledge conceptions have been extended by the researchers in mathematics education (Lannin et al., 2013). It was described that mathematical knowledge for teaching composes subject matter knowledge and pedagogical content knowledge (Hill et al., 2008a; Hill et al., 2008b). While subject matter knowledge consists of common content knowledge, specialized content knowledge, and knowledge at the mathematical horizon, pedagogical content knowledge is divided into subcategories such as knowledge of content and students, knowledge of content and teaching, and knowledge of curriculum (Hill et al., 2008a). Another conceptual framework produced by TEDS-M (Teacher Education and Development Study–Learning to Teach Mathematics) discusses the knowledge for teaching mathematics via two conceptions, which are (i) mathematics content knowledge, and (ii) mathematics pedagogical content knowledge (Tatto et al., 2008). In this study, we used the relevant literature on pedagogical content knowledge of prospective secondary mathematics teachers while analyzing the lesson plans.

Pedagogical content knowledge “represents the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organized, represented and adapted to the diverse interests and abilities of learners, and presented for instruction” (Shulman, 1986, p. 8). Components of the pedagogical content knowledge are knowledge of content and students, knowledge of content and teaching, knowledge of curriculum (Hill et al., 2008a). One of the components of pedagogical content knowledge is the knowledge required for designing a proper mathematics lesson (Prescott, Bausch, & Bruder, 2013). To obtain an effective teaching, it is necessary to prepare a mathematics lesson plan. The main reasons why a lesson plan is prepared include ensuring the efficiency of the lesson and making the lesson effective based on the given time (Gall & Acheson, 2011). However not only preparing a good lesson plan is enough but also teacher must tackle with the challenges that may encounter in the classroom and adjust according to these challenges (Akyuz, Dixon, & Stephan, 2013). Since lesson plans help teachers to document their ideas on teaching and share and use them for upcoming years, having knowledge on lesson plan is important, especially for prospective mathematics teachers, who are at the beginning of their professional career (Cole & Knowles, 1993; Feiman-Nemser & Parker, 1990). As they might have difficulties for adapting themselves to understand the students’ profile, needs and classroom management in their first years of their teaching getting prepared lesson plans before the classes would be helpful for them.

Literature shows that lesson planning is necessary for effective teaching (Akyuz, Dixon, & Stephan, 2013; Ozogul & Sullivan, 2009; Ruys, Keer, & Aelterman, 2012; Thompson, 1984). Thompson (1984) addressed the responsibilities of a teacher such as directing and controlling all instructional activities according to a clear lesson planning. Rusznyak and Walton (2011) addressed the importance of guidelines for preparing lesson plan to help teachers to overcome the difficulties of preparation. Zıngır Gülten (2013) explored the first lesson planning experience of the English teacher trainees’ and identified their reactions. She found that lesson planning experience has a positive impact upon the teacher trainees. However, teacher trainees’ have challenges on the process such as timing difficulties, problems in sequencing and selecting activities, providing effective transitions and finding sources. Panosuk, Stone, and Todd (2002) investigated middle school mathematics teachers’ implementation process of lesson plans. They found that the most challenging part of lesson planning is based on mathematical concepts. Baylor, Kitsantas, and Chung (2001) proposed a tool to help prospective teachers to determine their self-regulatory strategies in the process of lesson planning. Bümen (2007)

explored prospective teachers' lesson planning skills with original and revised version of Bloom's taxonomy. Azizoğlu (1989) conducted a research on the opinions of elementary teachers about lesson planning and he revealed that teachers considered lesson planning not necessary and they had limited competence on lesson plans. There are studies suggesting that lesson planning guidelines and template help teachers to scaffold the construction of their pedagogical content knowledge individually and construct the basic concepts of inclusive education (Causton-Theoharis, Theoharis, & Trezek, 2008; Rusznyak & Walton, 2012). Ruys, Keer and Aelterman, (2012) explored the quality of lesson planning on the implementation of collaborative learning. Zaskis, Liljedahl, and Sinclair (2009) addressed that lesson plans are too structured and limited to allow teachers preparing for teaching and to make students think and ask questions. In their study they provide teachers occasions for analyzing their actions and students thinking through lesson plays (Zaskis, Liljedahl, & Sinclair, 2009). Regarding these issues there has been limited research exploring prospective teachers' lesson planning process specifically for mathematics education at high school level. In this study an insight into prospective teachers' experiences during lesson planning is given. We have focused on prospective mathematics teachers' knowledge of mathematics lesson plans that is one of the components of pedagogical content knowledge, and prospective teachers' experiences while designing the lesson plan. Within this context, we have formulated our research question as "How do the prospective secondary mathematics teachers design a lesson plan by using their pedagogical content knowledge?"

The sub-questions of the research questions are:

- (i) How do prospective secondary mathematics teachers design a lesson plan?
- (ii) What are the experiences of the prospective secondary mathematics teachers while designing a lesson plan?

METHODOLOGY

Research Method

We have conducted this qualitative study with 60 prospective secondary mathematics teachers studying a five-year teacher education program at the Secondary Science and Mathematics Education department of a state university in Turkey. This study is a qualitative research as we applied this approach mentioned in (Denzin & Lincoln, 2000) that study things in their natural settings, attempting to make sense of or to interpret, and phenomena in terms of the meanings people bring to them. Considering the purpose and research questions, phenomenology design was employed (Creswell, 2005; Patton, 2002) since the purpose of the phenomenology design "is to understand and describe a specific phenomenon in-depth and reach at the essence of participants' lived experience of the phenomenon" (Yüksel & Yıldırım, 2015, p.3).

Participants

We have collected data from 60 prospective secondary mathematics teachers in "Teaching Methods in Mathematics Education" course, which is given in the 8th semester of the programme. The instructor of that course is a Professor in Mathematics Education and has been teaching this course for 10 years. Participants of the study were 22-23 years old and 45 of them were female and 15 of them were male. We have also interviewed eight prospective teachers in pairs (4 pairs) together with the partners with whom they prepared their lesson plans. We selected eight prospective teachers as participants besides having them as volunteers, to be part of the study; they were curious, questioning and, enthusiastic about teaching and implementing the new teaching methods that they have learned during the Teacher Education program. The prospective secondary mathematics teachers have completed most of the mathematics content courses contained within their programs including algebra, geometry, calculus, and analysis. Besides, they have also taken most of the pedagogy courses such as developmental

psychology, classroom management, counseling and, approaches and theories of teaching and learning. After completing these courses, the prospective secondary mathematics teachers have completed courses such as technologies and material design, and mathematics teaching consisting of modeling, problem solving, abstraction, generalization, mathematical understanding, nature of mathematics, and preparing activities required for teaching mathematics, all of which combine mathematical knowledge with pedagogical knowledge. We gave prospective teachers acquisitions to prepare lesson plans that include “exponential function concept, parabola, ellipse, and hyperbola concept, concepts of definition, axiom, theorem, and proof, concept of inner product, concept of sequence, concepts of ratio and proportion, concept of trigonometric functions” which are included in the mathematics curriculum. Therefore, we could conclude that prospective mathematics teachers almost have the knowledge of pedagogy and content. During the Teaching Method Course, instructors aim to make prospective teachers to combine their pedagogy and content knowledge.

Implementation Process of the Teaching Methods Course

The course, which lasts for 14 weeks, is carried out in three stages. In the first stage, the instructor of the Teaching Methods in Mathematics Education course makes an introduction to the Turkish secondary mathematics curriculum, the skills the curriculum aims to gain, and how to read and interpret the acquisitions that are deemed as the national standards in the Turkish curriculum (MONE, 2013). Then in the second stage, the instructor informs the prospective teachers of the lesson plan, which includes the aim, structure and content of lesson plan. In the last stage, the prospective teachers prepare lesson plans in pairs, according to the acquisition selected from the curriculum, and present their lesson plans in the classroom. The prospective teachers prepared their lesson plans in pairs based on the acquisition in the curriculum that was provided by their instructor. While the students presented the lesson plans they prepared the other students watched and criticized the content and structure of the lesson plans being presented. At the end of the course, the prospective students evaluated each group according to the “Lesson Plan Assessment Tool” which was prepared by the researchers and included the structure of the lesson plan, methods and strategies, motivation, activities, knowledge of content, association with other courses, evaluation, and assessment.

Data Collection Tools and Analysis

After the teaching methods course was completed, we have used document analysis to examine how the 60 prospective teachers organize their lesson plans (Bowen, 2009). We have also interviewed eight prospective teachers in pairs – the partners with whom they prepared their lesson plans. One of the questions that we asked in the videotaped interviews was “Can you discuss the experiences you obtained while preparing a lesson plan?” We have only focused on the data regarding the difficulties prospective teachers experienced while designing a lesson plan. We have assigned each participant a number from 1 to 60 in the findings. We have coded each prospective teacher as PT_x. Here, x refers to the number that we have assigned each prospective teacher.

We have systematically reviewed and evaluated the documents, in other words the lesson plans of the prospective teachers. The raw data were primarily divided into meaningful units, then coded and categorized as described by Patton (2002), with the aim of gaining understanding about the research problem. In this study, we used the relevant literature while analyzing the lesson plans of the prospective secondary mathematics teachers. For instance, we analyzed the lesson plans by dividing them into three sections: (i) Introduction and motivation, (ii) Teaching practice and (iii) Evaluation and assessment. According to prospective mathematics teachers’ lesson plans we determine the sub-categories of their lesson plans.

FINDINGS

Prospective secondary mathematics teachers' knowledge on preparing a lesson plan

In this section, we have discussed the prospective mathematics teachers' knowledge on preparing a mathematics lesson plan. We have divided prospective teachers' knowledge of preparing mathematics lesson plans into three categories, which are (i) introduction and motivation, (ii) teaching practice, and (iii) evaluation and assessment (see Table 1).

Table 1. Prospective Secondary Mathematics Teachers' Knowledge on Preparing a Lesson Plan

| Categories | Sub-categories |
|------------------------------------|--|
| Introduction and motivation | Videos Questions related to previous subjects Historical development of the concept Manipulatives Real life examples |
| Teaching practice | Group working Exploring activities (e.g. modeling, generalization, abstraction, proof) Dynamic mathematics software Alternative activities for the low and high ability students Manipulatives |
| Evaluation and assessment | Problems Questioning of the concepts Self-assessment forms Concept map Diagnosing students' conceptions |

Introduction and Motivation

Prospective mathematics teachers tended to use videos in the introduction and motivation part of the lesson plan. For example, one of the groups prepared a lesson plan for exponential function concept, which is included in the mathematics curriculum of the 11th grade (MONE, 2013). They planned to present the video, which was related to exponential function.



Figure-1. The graph, which states the time and number of ping pong balls.

The video explains exponential growth by setting off a chain reaction with a mechanism by using ping pong balls. It demonstrates how only one ping pong ball could affect other 225 ping pong balls in armed mouse traps. Figure 1 shows the graph, which states the time and number of ping pong balls. The video is taken from the 2008 Royal Institution Christmas Lectures (ProfChrisBishop, 2009).

The prospective teachers also used *questions related to the previous subjects* at the beginning of the lesson. They enabled their students to remember their previous knowledge before beginning the lesson. Some of their statements regarding the lesson plans are as follows:

“Teacher asks students questions about the subject of the previous lesson, which are the concept of circle and concepts related to circle such as chord, arc, diameter secant, and tangent.” (A part of 10th grade lesson plan for center, inscribed, tangent cord angle concepts, prospective teacher 6).

“Teacher asks questions about the concept of prism. Also, teacher asks questions about the area formulas of square, triangle, rectangle, and hexagon; then receives answers from students.” (A part of 10th grade lesson plan for surface areas and volumes of right prisms and right pyramids, prospective teacher 16).

Prospective teachers provided students with *the historical development of the concepts* in their lesson plans. They presented some basic information with regards to how the concept is developed and who contributed to the development of the concept. For instance, one of the groups explained who used the notations of complex numbers for the first time:

“In the 16th century, Gerolamo Cardano introduced negative solutions such as $a + \sqrt{-b}$ to cubic equations and the notation $i = \sqrt{-1}$ was used by Leonhard Euler for the first time in the 18th century.” (A part of 10th grade lesson plan for imaginary numbers and complex numbers, prospective teacher 23).

One group of the prospective teachers used a *manipulative* at the beginning of their lesson plan. This lesson plan targets to make the students define parabola, ellipse, and hyperbola as stated in 12th grade level mathematics curriculum (MONE, 2013). This group preferred to use manipulative visualizing conic sections at the introduction and motivation part.



Figure-2. Manipulative illustrates ellipse

The manipulative which was generated by leszek Rogaliński (2012) is shown in Figure 2. It illustrates a cone and its sections including parabola, ellipse, and hyperbola. This manipulative scene is from the video was used by the prospective teachers in their lesson plan. Figure 2 demonstrates the case where the intersection of the surface of a cone and a plane produce an ellipse.

Several prospective teachers gave *real life examples* in their lesson plans. They explained how these concepts were used in technology and sciences and they also provided specific examples from everyday life. The following quotations are from the lesson plans:

“Teacher asks students to give examples of cyclic events from their everyday life. Possible answers that students could give include seasons, days, months, clocks etc. Then teacher shares some pictures with the classroom.” (A part of 11th grade lesson plan for modular arithmetic, prospective teacher 17).

“Teacher presents students some pictures related to the concept of continuity such as a bridge and a damaged bridge, a chain and a broken chain. Then teacher ask students for their views

on these pictures.” (A part of 12th grade lesson plan for continuity of functions, prospective teacher 35).

Most of the prospective mathematics teachers are successful at designing the introduction and motivation part of the lesson plan. They utilize videos, questions related to previous subjects, historical development of the concept, manipulatives and real-life examples while designing their lesson plans. They encounter difficulties related with mathematical concepts while designing their lesson plan and the instructor of the course help them to overcome these difficulties on mathematical concepts. For instance, prospective teachers use manipulatives in their lesson plans to visualize conic sections for the concept of parabola, ellipse, and hyperbola to cope with the challenges on the concept.

Teaching Practice

All the prospective teachers used student-centered activities in the teaching practice part of their lesson plans. For instance, one of them designed *group working* activities by using the jigsaw technique. They prepared a lesson plan for the concepts of definition, axiom, theorem, and proof from the mathematics curriculum of the 11th grade (MONE, 2013) in teaching methods course. If there were 25 students in the classroom, they divided the students into five groups for the activities. Then, the students in each group drew a color card, and then they were divided into new groups. The prospective teachers asked each group to investigate whether the statement given to them is an axiom or a theorem. For instance, “1 is a natural number” was the statement of the purple card group. Lastly, they went back to their previous group and shared their views with each member of the group.

The prospective teachers mostly used *exploring activities* in their lesson plans. Modeling, problem solving, generalization, abstraction, and proof are some examples to these activities. One of the groups prepared an activity, which aimed to enable the students to generalize the properties of inner product in Euclidean plane in the mathematics curriculum of the 12th grade (MONE, 2013).

| \vec{u} | \vec{v} | \vec{y} | $\langle \vec{u}, \vec{v} \rangle + \langle \vec{u}, \vec{y} \rangle$ | $\langle \vec{u}, \vec{v} + \vec{y} \rangle$ |
|-----------|-----------|-----------|---|--|
| (1,3) | (3,-1) | (4,-4) | | |
| (2,8) | (-1,5) | (0,1) | | |
| (11,-3) | (-8,9) | (1,2) | | |
| (2,0) | (0,4) | (1,1) | | |
| (3,4) | (1,12) | (2,2) | | |
| (3,99) | (7,6) | (1,1) | | |
| (4,10) | (-3,4) | (-1,3) | | |
| (-1,17) | (6,-9) | (3,4) | | |
| (-6,-7) | (9,-6) | (5,6) | | |
| (0,3) | (4,4) | (6,5) | | |

Figure-3. The activity related to concept of inner product.

This activity contains all properties of the inner product and the recommended time duration for this activity is 35 minutes in the lesson plan. Figure 3 presents a table included in the activity, which was planned to be implemented as an individual work by the prospective teachers. After the students filled in table, the prospective teachers planned to ask “Let \vec{u} , \vec{v} and \vec{y} be vectors in \mathbb{R}^2 . Show $\langle \vec{u}, \vec{v} \rangle + \langle \vec{u}, \vec{y} \rangle = \langle \vec{u}, \vec{v} + \vec{y} \rangle$ ” in the activity.

The prospective teachers preferred to use *dynamic mathematics software* such as Geometer's Sketchpad, Cabri 3d, and GeoGebra. One of the groups designed a material for exponential functions in the mathematics curriculum of the 11th grade (MONE, 2013). Two sections of the material designed in GeoGebra are as follows:

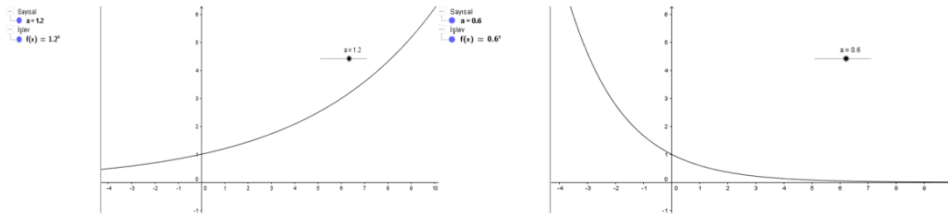


Figure-4. Two sections of the material designed in GeoGebra.

Students could observe how to change the graph of a function that is $f(x) = a^x$ defined while slider tool works for different values of a constant. Figure 4 illustrates two values, which are 0,6 and 1,2 for a constant. The slider tool takes integer values between -5 and 5.

Some of the prospective teachers considered *alternative activities for the low and high ability students*. To exemplify, one of the groups designed an alternative activity for the high ability students in a lesson plan for the concept of function in the mathematics curriculum of the 10th grade (MONE, 2013). “Find the function f , which defines the distance of the point $A(4,0)$ to the line $y = x + 2$ ” was the one of the problems in this activity.

One of the groups used a *manipulative* in teaching practice part for the parabola, ellipse, and hyperbola concepts. They prepared a manipulative for all the groups in the classroom. The students could draw an ellipse with the help of this manipulative as displayed in Figure 5.

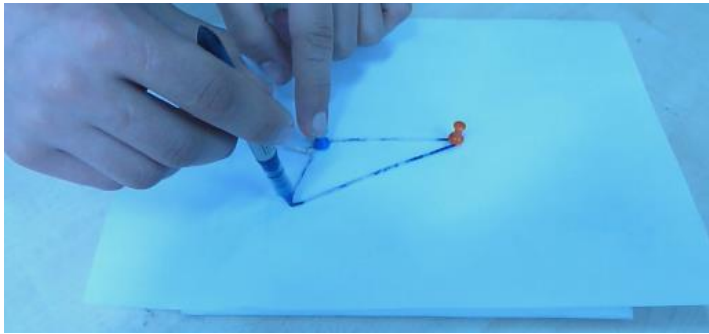


Figure-5. The manipulative that produces an ellipse

The manipulative is prepared with one A4 carton, two pins, one yarn that is long enough, and one pencil. It works quite simply. When the pencil moves around the pins, ellipse can be drawn on the carton. These pins represent the focal points of the ellipse.

Most of the prospective mathematics teachers are successful on designing the teaching practice part of the lesson plan. They utilize group working, exploring activities (e.g. modeling, generalization, and abstraction, proof), dynamic mathematics software, and alternative activities for the low and high ability students, manipulatives while designing their lesson plans. They especially have challenges of the mathematical concepts while designing their lesson plan and the instructor of the course support them to overcome their difficulties on the mathematical concepts. For instance, prospective teachers use a manipulative in teaching practice part for the parabola, ellipse, and hyperbola concepts which are challenging concepts.

Evaluation and Assessment

All the prospective teachers prepared *problems* for the evaluation and assessment part in their lesson plans. For example, one of the groups asked a problem about the concept of sequence in the mathematics curriculum of the 11th grade (MONE, 2013). Figure 6 displays the squares in the problem.

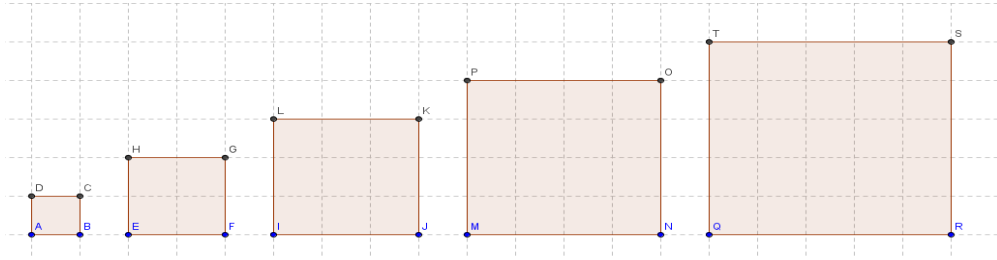


Figure-6. The square problem.

The problem was “Let $|AB| = 1$, then calculate the perimeters of the squares above. Write a sequence, whose elements are the perimeters of the squares.” Also, the group, which designed a lesson plan for concepts of definition, axiom, theorem, and proof, made a crossword for the evaluation and assessment part.

Most of the prospective teachers also organized an environment which had the aim of *questioning of the concepts*. They planned to ask the questions to the whole classroom. In fact, they tried to construct a context which involved conducting a conceptual discussion with all of the students. Here are some examples of the mentioned questions:

“Why do we need experimental probability when we could calculate a lot of things through theoretical probability?” (A part of the 12th grade lesson plan for the experimental and theoretical probability, prospective teacher 46)

“Suppose that one of your friends says, “the product of two irrational numbers is always an irrational number”, what would your opinion be? Is it correct or false?” (A part of the 9th grade lesson plan for the real and irrational numbers, prospective teacher 50)

One of the groups prepared a *self-assessment form* in the lesson plan for the concepts of ratio and proportion in the mathematics curriculum of the 9th grade (MONE, 2013). The prospective teachers wanted the students to evaluate themselves in terms of their learning situation. The prospective teachers also wrote their opinions on the students in their groups in these self-assessment forms.

Concept map was also used by one of the groups, which prepared a lesson plan for the concept of sequence. These prospective teachers asked the students to draw a concept map for the concepts, which was mentioned in the lesson plan. The concept map was supposed to include concepts such as sequence, finite sequence, and constant sequence.

One group of the prospective teachers prepared questions for *diagnosing conceptions of the students*. Firstly, they asked standard problems about the concept of trigonometric functions on the unit circle in the mathematics curriculum of the 11th grade (MONE, 2013). Then the prospective teachers proposed new problems according to the students' performance in the previous problems. They aimed to determine students' conceptions and gave feedbacks about the trigonometric functions on the unit circle.

Most of the prospective mathematics teachers are successful on designing the evaluation and assessment part of the lesson plan. They conduct different type of evaluation and assessment tools. They utilize problems, questioning of the concepts, self-assessment forms, concept map, and diagnosing students' conceptions while designing their lesson plans. They especially have challenges of the mathematical concepts while designing their lesson plan and the instructor of the course help them to

overcome their difficulties on the mathematical concepts. Therefore, prospective teachers give specific focus on questioning of the mathematical concepts in their evaluation and assessment tools to support students on mathematical conceptions.

Experiences of Prospective Mathematics Teachers while Designing a Lesson Plan

We have interviewed eight prospective teachers in pairs – the partners with whom they prepared the lesson plans, at the end of the course. In addition to being participants, they were volunteered to be part of the study as they were curious, questioning and enthusiastic about teaching, and implementing the new teaching methods that they have learned during the Teacher Education program. In this section, we will only discuss experiences of prospective teachers while designing their lesson plan. They highlighted with what parts they had difficulty with while preparing the components of the lesson plan by stating the following:

“PT₁: We realized that we had problems with the concepts of definition, theorem, axiom and proof. Is it an axiom or a theorem?”

PT₂: We had difficulties especially while preparing the evaluation part. Then, we designed an entertaining crossword.”

“PT₅: We couldn’t define the limit in the activity that we planned. Our mathematical content knowledge of the concept of limit was not enough for the lesson plan.

PT₆: When we asked the lecturer, he said “where is the independent variable? We couldn’t answer the question. Then we re-organized the activity according to the feedback received in the classroom discussion.”

As seen above, the prospective secondary mathematics teachers stated that they had difficulties with the concept itself. They had to review and revise their own mathematical content knowledge during the teaching methods course. The prospective teachers also explained how they started to plan their lesson plans by uttering the following:

“PT₃: We considered using a manipulative because infinity is an abstract concept. We firstly used chickpeas and we said “no, it is not working”. We realized that we had difficulties with the concept of infinity. Then we decided to present a video related to the fractals.

“PT₄: In order not to memorize the rules, we insisted on gaining different points of views for the students. We tried to raise the awareness of students as well as to give real life examples in the lesson plan”

“PT₇: We firstly tried to find a manipulative for the relationship between definite integral and indefinite integral, but we couldn’t find any. Then, we thought that we did not need a manipulative and decided to extend the activities.

“PT₈: Then, we found a video as a reminder of the previous subject. Then, we used this video for the attention-grabbing act at the beginning of the lesson plan.”

The prospective secondary mathematics teachers addressed how they decided to use sources in all parts of the lesson plan. They changed the components of the lesson plans according to both concept itself and the materials. The prospective teachers also declared that they tried to organize the lesson plan through student-oriented approaches.

CONCLUSION AND DISCUSSION

In this study, we have focused on prospective mathematics teachers' knowledge of mathematics lesson plans, and their experiences while designing a lesson plan. For the introduction and motivation part of the lesson plan, most of the prospective teachers used videos and asked questions about the previous subjects. Some of the prospective teachers provided real life examples and showed manipulatives to motivate students. Furthermore, the students were provided with information regarding the historical development of the concepts. All the prospective teachers designed teaching practice through group work. They came up with activities, which would enable students to explore by themselves. These exploring activities included mathematical processes such as modeling, problem solving, proving, abstraction, and generalization. The prospective teachers mostly designed teaching practices by using dynamic mathematics software. Some of the prospective teachers carried out alternative activities for both low and high ability students. Lastly, manipulatives were used in the teaching practice of the lesson plans. The prospective teachers often used problems for the evaluation and assessment part. Some of the prospective teachers evaluated students' understanding through questioning the concepts and the concept map. Self-assessment forms and diagnosing conceptions of the students were also employed in the evaluation and assessment category. Especially the prospective teachers, whom we have interviewed, insisted that not having enough mathematical content knowledge could affect the whole structure of the lesson plan.

The findings suggest that the prospective secondary mathematics teachers' knowledge of mathematics lesson plans is influenced by the student-oriented approaches. The prospective teachers preferred to use technology and manipulatives almost in all components of their lesson plans. The prospective teachers organized lesson plans according to both individual differences and mathematical processes, which may be due to their background resulting from the courses they studied. The instructor of the teaching methods course also emphasized the significance of the mathematical processes and constructivist approaches at the beginning of the course. It is possible to say that prospective teachers used not only their own knowledge of content and teaching; but also, their knowledge of curriculum, and knowledge of content and students (Hill, et al., 2008a). We found that prospective mathematics teachers have difficulties related with the mathematical concepts while designing their lesson plan. This result is consistent with the findings of Panosuk, Stone and Todd (2002) who concluded that the most challenging part of lesson planning is based on mathematical concepts. Thus, prospective mathematics teachers need support to overcome these conceptual difficulties. As opposed to results of Azizoğlu's research (1989) who revealed that teachers believed lesson planning was not necessary and had limited competence on lesson plans, we found that prospective mathematics teachers believed lesson planning was necessary and they improved their competence on planning.

We believe that it could be useful to provide prospective teachers with feedback so as to support the development of their knowledge of lesson plans, as stated in the literature (Ruszynak & Walton, 2011). Besides, it would be helpful for teachers to give them support about how to cope with the challenges that they may encounter in the classroom and to adjust according to these challenges (Akyuz, Dixon, & Stephan, 2013). In addition to this prospective mathematics teachers should be supported for overcoming their conceptual difficulties on lesson planning. Working on teaching scenarios and/or video analysis including conceptual discussion based on specific concepts might be useful for prospective teachers during their education. Analysis of video-clips enables prospective teachers to identify the classroom interaction, student thinking and their own teaching (Zazkis, Liljedahl, & Sinclair, 2009). Thompson (1984) suggested that studies are needed to investigate the teachers' mathematical conceptions in relation to grade level, students' academic level and the mathematical content. Besides, another research should be conducted on whether the teachers' mathematical conceptions influence the students' conceptions of mathematics (Thompson, 1984). Further researches

which will provide significant implications for both prospective teachers and teacher educators, could investigate how prospective mathematics teachers use lesson plans in teaching. These researches would be significant contribution to the literature regarding the preparation of prospective mathematics teachers' lesson plans and their implementation in the classroom while they are in the first years of their profession.

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Matematik Öğretmen Adaylarının Ders Planı Tasarlama Süreçleri

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Genişletilmiş Özet: Matematik öğretmen adaylarının, üniversitede aldıkları öğretmenlik eğitimleri ile birlikte öğrencilerle yaşadıkları sınıf tecrübesinde belirli pedagojik stratejileri kazanmaları beklenmektedir. Kendi geçmiş öğrencilik tecrübeleri ve üniversitede aldıkları öğretmenlik eğitimi, öğretmen adaylarının matematik öğretimlerine yönelik perspektiflerini önemli ölçüde etkilemektedir (Barkatsas & Malone, 2005). Öğretmen eğitimi programları öğretmen adaylarının matematiksel içerik ve genel olarak öğretim ile ilgili yeni perspektifler kazanmalarını sağlamaktadır (Prescott, Bausch, & Bruder, 2013). Öğretmen eğitimi programlarında öğretmen adaylarına kazandırılması hedeflenen pedagojik alan bilgisinin bileşenlerinden biri de ders planı hazırlama bilgisidir. Ders planları öğretmenlerin fikirlerini düzenli bir şekilde aktarmalarına, paylaşmalarına fırsat verir ve ayrıca gelecek yıllardaki öğrencilerine ve sınıflarına göre adapte ederek kullanmalarına imkân sağlar. Var olan literatür göstermektedir ki, etkili bir öğretim için ders planı hazırlamak oldukça gereklidir (Akyuz, Dixon, & Stephan, 2013; Ozogul & Sullivan, 2009; Ruys, Keer & Aelterman, 2012; Thompson, 1984). Öğretmenlerin pedagojik alan bilgilerini kendi derslerinde kullanmak üzere yapılandırmalarına yardımcı olacak ders planı hazırlama rehberi ve şablonu öneren çalışmaların literatürde yer aldığı görülmektedir (Causton-Theoharis, Theoharis, & Trezek, 2008; Rusznyak & Walton, 2012). Fakat incelenen bu literatürde lise matematik öğretmen adaylarının ders planı hazırlama süreçlerini inceleyen sınırlı sayıda çalışma olduğu söylenebilir. Bu çalışmada, matematik öğretmen adaylarının pedagojik alan bilgisinin bileşenlerinden birisi olan ders planı bilgisine ve ders planı hazırlama süreçlerine odaklanılmıştır. Araştırmanın problemi ise “Lise matematik öğretmen adayları pedagojik alan bilgilerini kullanarak ders planlarını nasıl tasarlamaktadırlar?” şeklinde formüle edilmiştir.

Bu nitel çalışmanın katılımcıları Türkiye’de bir devlet üniversitesinin ortaöğretim fen ve matematik alanları eğitimi bölümü, matematik eğitimi anabilim dalının 5. Sınıfında okuyan 60 matematik öğretmen adaydır. Araştırmanın amacı ve problemi göz önünde bulundurulduğunda, araştırmanın deseni fenomenoloji olarak belirlenmiştir (Creswell, 2005; Patton, 2002). Araştırmanın verileri 60 lise matematik öğretmen adayından, 8. öğretim döneminde, özel öğretim yöntemleri dersi kapsamında toplanmıştır. Dersi veren öğretim üyesi matematik eğitimi alanında profesördür ve bu dersi 10 yıldır vermektedir. Araştırmanın katılımcıları, 22-23 yaşlarında olan 45 kadın ve 15 erkekten oluşmaktadır. Ayrıca sekiz öğretmen adayıyla (4’lü gruplar halinde) ders planı hazırlama süreçleri üzerine görüşme yapılmıştır. 8 öğretmen adayı, çalışmaya katılmaya gönüllü olmakla birlikte, meraklı, sorgulayan, yeni öğretim metotlarını uygulamaya hevesli olmalarından dolayı görüşme yapmak için seçilmiştir. Matematik öğretmen adayları cebir, geometri, temel matematik ve analiz gibi birçok pür matematik dersini ve ayrıca, gelişimsel psikoloji, sınıf yönetimi, rehberlik ve öğrenme ve öğretim yaklaşımları gibi birçok eğitim dersini almışlardır. Bu dersleri tamamladıktan sonra, teknoloji ve materyal tasarımı, modelleme, problem çözme, soyutlama, genelleme, matematiksel anlama, matematiğin doğasını içeren matematik öğretim teorilerini ve etkinlik hazırlamak için gerekli uygulamalar içeren matematik ve eğitim bilgilerini birleştirip kullanmaları gereken dersleri almışlardır. Matematik öğretmen adaylarına ders planlarını hazırlamaları için lise matematik öğretim programından kazanımlar verilmiştir. Bu kazanımlar “üstel fonksiyon, parabol, elips, hiperbol, aksiyom, teorem, ispat, iç çarpım, seriler, oran ve orantı, trigonometrik fonksiyonlar” kavramlarını içermektedir. Sonuç olarak öğretmen adaylarının ders

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planı tasarlamaya başlamadan önce eğitim ve matematik ile ilgili bütün bilgilere sahip olduğu söylenebilir. Özel öğretim yöntemleri dersi kapsamında ise dersin öğretim üyesi, öğretmen adaylarından eğitim ve matematik ile ilgili bilgilerini birleştirmelerini beklemektedir. Araştırmada özel olarak öğretmen adaylarının ders planı hazırlama sürecinde yaşadıkları zorluklara da odaklanılmıştır. Öğretmen adaylarının hazırladıkları ders planları, ilgili literatürden faydalanılarak analiz edilmiştir. Ders planları üç kategoriye ayrılarak incelenmiştir: (i)Giriş ve motivasyon, (ii)Öğretim uygulamaları, (iii)Ölçme ve değerlendirme. Öğretmen adaylarının hazırladıkları ders planlarının analizi sonucu ise alt kategoriler oluşturulmuştur.

Araştırmanın sonuçlarına göre, giriş ve motivasyon kategorisinin alt kategorileri i) videolar, ii) geçmiş konularla ilgili sorular, iii) kavramların tarihsel gelişimi, iv) manipülatifler, v) gerçek hayat örnekleri olarak tespit edilmiştir. Öğretim uygulamaları kategorisinin alt kategorileri i) grup çalışması, ii) keşfetme etkinlikleri (ör. modelleme, genelleme, soyutlama, ispat), iii) dinamik matematik yazılımları, iv) düşük ve yüksek seviyedeki öğrenciler için alternatif etkinlikler, iv) manipülatifler olarak belirlenmiştir. Ölçme ve değerlendirme kategorisinin alt kategorileri i) problemler, ii) kavramları sorgulama, iii) bireysel değerlendirme formu, iv) kavram haritası, v) öğrenci kavramalarını teşhis etme olarak ortaya çıkarılmıştır. Analizler sonucu ortaya çıkarılan kategoriler ve alt kategoriler Tablo 1 de verilmiştir.

Tablo 1. Lise Matematik Öğretmen Adaylarının Ders Planı Hazırlama Bilgileri

| Kategoriler | Alt kategoriler |
|-------------------------------|---|
| Giriş ve motivasyon | Videolar Geçmiş konularla ilgili sorular Kavramların tarihsel gelişimi Manipülatifler Gerçek hayat örnekleri |
| Öğretim uygulamaları | Grup çalışması Keşfetme etkinlikleri (e.g. modelleme, genelleme, soyutlama, ispat) Dinamik matematik yazılımları Düşük ve yüksek seviyedeki öğrenciler için alternatif etkinlikler Manipülatifler |
| Ölçme ve değerlendirme | Problemler Kavramları sorgulama Bireysel değerlendirme formu Kavram haritası Öğrenci kavramlarını teşhis etme |

Araştırmanın sonuçları göstermektedir ki, öğretmen adaylarının öğrenci merkezli ve teknoloji tabanlı etkinlikleri tercih etmektedir. Örneğin, matematik öğretmen adaylarının modelleme, genelleme, soyutlama ve ispat yapma ile ilgili etkinliklerini grup çalışması kullanarak uyguladıkları tespit edilmiştir. Ayrıca matematiksel kavramları somutlaştırmak ve öğrencilerin anlamasına yardımcı olmak için manipülatifler kullandıkları görülmektedir. Öğretmen adaylarının ders planı hazırlama sürecinde, öğrencilerin anlamalarını ve önceki bilgilerini de göz önünde bulundurdıkları tespit edilmiştir. Ayrıca öğretmen adaylarının ders planı hazırlarken matematiksel kavramlarla ilgili matematiksel içerik bilgisinden kaynaklı zorluklar yaşadıkları belirlenmiştir. Görüşme yapılan öğretmen adayları matematiksel kavramlarla ilgili bilgilerin eksik olmasının tüm ders planı tasarlama sürecini etkileyeceğini vurgulamışlardır. Literatürde de belirtildiği üzere, öğretmen adaylarının ders planı

hazırlama bilgilerini desteklemek için onlara dönütler vermenin oldukça faydalı olacağı düşünülmektedir (Ruszynak & Walton, 2011). Ayrıca öğretmen adayları ders planı hazırlama sürecinde matematiksel kavramlarla ilgili karşılaştıkları zorluklar konusunda desteklenmelidir.

Anahtar Kelimeler: Matematik öğretmen adayları, Ders planı, Pedagojik alan bilgisi, Öğretmen eğitimi