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# Awareness of Misconceptions in Science and Mathematics Education: Perceptions and Experiences of Pre-service Teachers [*]

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**ABSTRACT**

This study aimed to reveal elementary science and mathematics pre-service teachers' perceptions and experiences on misconceptions. To what extent pre-service teachers are aware of students' misconceptions, and what they experienced about identifying and working with misconceptions were of interest for this study. Semi-structured interviews were conducted with 11 pre-service teachers from elementary science education and mathematics education programs. The results revealed that pre-service teachers had awareness on nature of misconceptions while having difficulties in providing more concise definitions of misconceptions. The misconceptions were mostly realized while giving additional examples compared to students' explanation during teaching learning process. Another finding showed pre-service teachers believed that misconceptions might lead to academic underachievement, can have impact on other topics, can create negative symptoms of psychology, and classroom management problems. The findings were further structured into a SWOT analysis framework that can help future researchers.

**Keywords:** misconceptions, teacher education, science and mathematics education, qualitative research

# Fen ve Matematik Eğitiminde Kavram Yanılgıları Üzerine Farkındalık: Öğretmen Adaylarının Algı ve Deneyimleri

**ÖZ**

Bu çalışma, fen ve matematik öğretmen adaylarının kavram yanılgıları hakkındaki algılarını ve deneyimlerini ortaya çıkarmayı amaçlamaktadır. Öğretmen adaylarının öğrencilerdeki kavram yanılgılarının ne kadar farkında oldukları ve kavram yanılgılarını belirlerken ve kavram yanılgıları ile çalışırken neler deneyimledikleri bu çalışmanın kapsamı içerisindedir. Fen ve matematik eğitimi bölümlerinden 11 öğretmen adayları ile yarı yapılandırılmış görüşmeler gerçekleştirilmiştir. Çalışmanın sonuçları göstermektedir ki öğretmen adayları kavram yanılgılarının doğası ile ilgili bir farkındalığa sahip olmakla beraber tanımlama yapmakta zorlanmaktadırlar. Kavram yanılgıları sıklıkla ek örnekler yoluyla tespit edilmektedir. Öğretmen adayları kavram yanılgılarının sonuçlarını

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akademik başarısızlık, diğer konuları öğrenmeye olumsuz etki, psikolojiye olumsuz etki ve sınıf yönetimi sorunları olarak görmektedirler. Bulgular son olarak bir SWOT analizi ile geliştirilerek sunulmuştur. Sonuçlar aracılığı ile algı ve deneyimlerinin ortaya konması öğretmen adaylarının geliştirilebilir yönlerine işaret etmektedir.
**Anahtar kelimeler:** kavram yanılgıları, öğretmen eğitimi, fen ve matematik eğitimi, nitel araştırma

## INTRODUCTION

One of the important factors that impacts learners is what they already know (Ausubel, 1968; Svinicki, 1994). If the prerequisite knowledge is not rooted in strong theoretical or rule-based evidences, it can result in incorrect judgments. Accordingly, *misconceptions*, in other words naïve understanding (Badenhorst, Mamede, Hartman, & Schmidt, 2015), or unwanted obstacles (Smith, diSessa, & Roschelle, 1993) for learning might arise. Preventing the occurrence of misconceptions, building on them or addressing them during instruction are critical for effective learning. When teachers are competent in monitoring and addressing students' ideas, they can better connect students' previous-knowledge with the target scientific knowledge. Whether teachers -expert or novice- have the ability to detect and investigate students' misconceptions is a critical issue to be considered within efforts to improve student learning outcomes. How pre-service teachers perceive and experience misconceptions was in the scope of the current study which can improve their future students' learning process.

In Turkish context, studies are limited to instructional dimensions that focus on identification of misconceptions and elimination of them. However, challenging misconceptions and building instruction on them can also be beneficial as trying to tackle misconceptions. The teachers can put an effort to highlight errors as learning opportunities by using these errors and building on them (An & Wu, 2012). Misconceptions should be seen as resources that should be engaged in the instruction by the teachers as opposed to errors that should be replaced (Smith et al., 1993). There are only a few studies that focus on awareness of teachers on students' misconceptions, what they know about sources of misconceptions and what strategies they can use in order to work with them (Fisher, 1985). Therefore, it is essential to conduct more research on pre-service teachers' thinking on misconceptions; teachers have not been educated in misconceptions but who experienced them practically with students, and those who have some knowledge about misconceptions (Gomez-Zweip, 2008). This study aimed to help address this issue by exploring pre-service teachers' perceptions and experiences on student misconceptions in science and mathematics education.

Some sources of misconceptions can be listed as; using too much teacher-centered approach, lack of depth in curriculum, and teachers having misconceptions or irrelevant connectivity between subjects and concepts (Çepni, Ayvacı, & Keleş, 2000). Incorrect teaching practices and teachers' inadequate conceptual grounding may trigger misconception on children's thinking (McNeil & Alibali, 2005). Some other reasons behind misconceptions can be reported as

a) teaching through rules and principles, b) number of students in each class c) scholarly mistakes in the textbooks, and d) lack of examples given by the teacher (Küçük & Demir, 2009). Teachers should be careful in design of their instruction and in how they monitor their knowledge and experiences on misconceptions. Analyzing misconceptions while grading homework (An & Wu, 2012), providing examples or counter-examples (Osana & Royea, 2011) and questioning and examining student discourse (Billings & Fitzgerald, 2002; Bush & Karp, 2013) are some other exemplary effective strategies for realizing sources of misconceptions and promoting student thinking.

Teachers should be competent on how to distinguish lack of knowledge from misconceptions (Korur, 2015), and on sources and causes of misconceptions (Naah, 2015). However it was indicated that teachers do not have sufficient training on understanding misconceptions (Gomez-Zweip, 2008). Teachers are found to be unaware of misconceptions (Badenhorst et al., 2015; Naah, 2015) and to be unlikely to challenge their students' misconceptions in their instruction (Halim & Meerah, 2002). If students' initial ideas and beliefs are ignored or if the teacher cannot address students' prior knowledge during instruction, the students can easily revisit their misconceptions after the requirements of the class such as exams (Sawyer, 2005, p.2), and their learning can progress in an inaccurate direction (Bransford, Brown, & Cocking, 2000). These findings pointed to the fact that teachers can have difficulty in facilitating student learning when they are not clear on misconceptions. What pre-service teachers know about misconceptions and how they experience possible effective strategies to identify misconceptions were in the scope of the current study. Such findings can contribute to the literature by presenting current perceptions and experiences of pre-service teachers which can facilitate student learning ultimately.

**Purpose of the Study**

In light of the literature presented, the main purpose was to examine pre-service teachers' perceptions on and experiences with misconceptions. The current study intended to extend the literature; a) by illustrating what the pre-service teachers, who were newly graduate candidates, already know about misconceptions; and b) by presenting how pre-service teacher experience misconceptions within their experiences. The study was particularly interested in the following research questions:

a) What are the perceptions of pre-service science and mathematics teachers regarding misconceptions?

b) To what extent do pre-service science and mathematics teachers have experience on instructional strategies regarding misconceptions?

## METHODOLOGY

In the current study, a qualitative research design was followed (Patton, 2002; Seggie & Bayyurt, 2015). The qualitative studies allow the researchers to deep into issues and in-depth understanding of meanings and processes within the context (Maxwell, 2012). According to the research purpose, this design allowed

us to comprehend the understanding and perceptions of the mathematics and science pre-service teachers on misconceptions of middle school students in a profound way. By thinking aloud of their real life experiences, the participants had potentiality to explain their perceptions and thoughts to the researchers at first hand.

The study also made use of a SWOT analysis in order to investigate the current condition of pre-service teachers' knowledge and experiences with student misconceptions in relation to the teacher education programs. A SWOT analysis is effective in terms of identifying four critical aspects of an ongoing system which are strengths, weaknesses, opportunities, and threats.

**Participants**

The study was conducted at two public universities in Turkey. Totally 11 pre-service were included in the study; 6 of whom were science and 5 of whom were mathematics teachers (10 female, 1 male). The participants were selected by criterion sampling (Fraenkel, Wallen, & Hyun, 2012; Seggie & Akbulut-Yıldırmış, 2015, p.26). In line with this, pre-service science and mathematics teachers who had experiences with elementary school students were selected. Two disciplines; science and mathematics were specifically selected due to the fact that the researchers had experience and expertise on these two disciplines mainly. Pre-service teachers' experiences with students were from 2 to 6 years who were in 3rd grade ($n$ = 3) and 4th grade ($n$ = 8) in their teacher education programs. Majority of the participants reported that they prepared lesson plans before they worked with their students ($n$ = 6). These experiences contained one-to-one tutoring in private education centers that were used to refer to as 'dershane'. These centers have their legal status within Turkish Education System for about 50 years. They were maintained along with central examination systems and prepare children transition to higher level of schooling (Köprülü, 2014).

**Context of the Study**

There is not a special course offered on misconceptions in both of the universities in which the study was conducted. However pre-service teachers had an opportunity to cover "misconceptions" with examples and practices in the courses offered by the universities called *Teaching Mathematics/Science I-II*, *Principles and Methods of Instruction*, and *School Experience in Teaching Math and Science*. All pre-service teachers participated to the current study had taken these courses before.

Table 1. *Participants of the Study*

| Gender | Entrance year | Discipline | Years of experience in tutoring | Grade level for tutoring | | |
|---|---|---|---|---|---|---|
| | | | | Primary School [1-4] | Middle School [5-8] | High School [9-12] |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Teacher G | Male | 2008 | Math | 5 | | X | X |
| Teacher E | Female | 2010 | Math | 3 | X | X | X |
| Teacher K | Female | 2007 | Math | 7 | X | X | |
| Teacher M | Female | 2010 | Math | 4 | X | X | X |
| Teacher O | Female | 2009 | Math | 4 | X | X | X |
| Teacher S | Female | 2008 | Science | 3 | X | X | |
| Teacher E2 | Female | 2009 | Science | 4 | X | X | |
| Teacher F | Female | 2010 | Science | 4 | X | X | |
| Teacher Ö | Female | 2008 | Science | 5 | X | X | X |
| Teacher C | Female | 2009 | Science | 4 | X | X | X |
| Teacher T | Female | 2010 | Science | 3 | X | X | |

**Data Sources**

The data source used in this study was a semi-structured interview form developed by the researchers. Semi-structured interviews allow for systematic analysis of the data collected (Yıldırım & Şimşek, 2013). The interview form had 11 questions and consisted of two sections: 1) questions on personal information, and 2) questions on perceptions and experiences. The piloting of the interview form was conducted with research assistants (n=4) working in one public and one private university in Turkey. All interviews were completed in Turkish and later translated into English to prepare for data analysis. Necessary revisions to the interview questions were made following that procedure which resulted in the final interview form.

**Data Analysis**

The qualitative data was analyzed with content analysis (Strauss & Corbin, 1990; Kızıltepe, 2015) that included four stages: 1) coding of the data, 2) identification of the themes, 3) arrangement of the codes and the themes, and 4) description and interpretation of the findings. Prior to the content analysis, the transcription of the data verbatim was completed by the researchers. Then initial coding was completed and the researchers brainstormed on the possible categorizations of the codes and the themes. A codebook was created was to use in the final coding of the data. This stage included identification of the final codes and the themes and the calculation of their frequencies. In the final version of this codebook, there were 5 themes and 16 codes under these themes. The codes with low frequencies were later deleted which resulted in the final version of the themes and codes. Details on these themes and codes are provided in Table 2.

Table 2. *Themes and Codes in the Codebook*

1. Definition and Nature of Misconceptions
   1.a. Misunderstanding
   1.b. Coding Error
   1.c. Correcting Misconceptions
2. Mistakes and Misconceptions

3. Identifying and Working with Misconceptions
   3.a. Providing Additional Examples
   3.b. Making Students Active
   3.c. Using Visuals
   3.d. Recovering the Topic
   3.e. Being Attentive about Misconceptions Prior to Instruction
   3.f. Giving Real Life Examples
4. Sources of Misconceptions
   4.a. Generalizations by the Teacher
   4.b. Insufficient Examples in Instruction
   4.c. Ineffective use of Visual and Technological Materials
5. Consequences of Misconceptions
   5.a. Academic Underachievement
   5.b Impact on Other Topics
   5.c. Student Psychology
   5.d. Classroom Management Problems

**Trustworthiness**

Trustworthiness of the study was ensured through certain steps. Firstly, the interview form was evaluated and reviewed by a language and evaluation expert. The codebook generated by the researchers went through many revisions to guarantee reliability. The researchers discussed on adding, refining or deleting codes and themes. The final version of the codebook included agreed upon themes, codes, definitions and example quotations. In order to check for the reliability of the findings, the researchers first analyzed the data individually and later came together to discuss their individual analysis process focusing on similarities and differentiations. The inter-rater reliability for the codes was calculated as 74% which was interpreted as appropriate (Krippendorf, 2004). Finally, two of the participants of the study were accessed after data analysis for a discussion on the findings of the study, which provided member check.

## RESULTS AND DISCUSSION

The data analysis revealed five themes: (1) definition and nature of misconceptions, (2) mistakes and misconceptions, (3) identifying and working with misconceptions, 4) sources of misconceptions, and (5) consequences of misconceptions. These themes helped to organize and interpret pre-service teachers' perspectives and experiences on misconceptions in mathematics and science education.

**Definition and Nature of Misconceptions**

Three codes emerged in this theme; 1) misunderstanding, 2) coding error, 3) correcting misconceptions. As for misunderstanding, for one third of the pre-service teachers, a common description was that difficulty in understanding the topics was associated with misconceptions. They stated that difficulty connects to partial understanding of the topics which then results in a misconception. One

of the pre-service teachers expressed: "*The students do not know what a topic includes, or when and how that topic will contribute to their learning. Students might know the topic but they have misunderstandings and they misinterpret it. So they have misconceptions."* At this point, the pre-service teachers seemed to focus on a broad definition such as incorrect understandings to describe misconceptions. One of the participants, however, had a more specific description; *'Students make their own thinking patterns and rely on that. Misconceptions are like misunderstanding some topics.'*

Coding error was mentioned by approximately one fifth of the pre-service teachers. One of the pre-service teachers commented; '*students rely on their previous existing cognitive codes and they match the new material with incorrect codes.'* The thinking of pre-service teachers tends to linking incorrect cognitive schemas with misconceptions. This might be due to the courses related to educational sciences they took recently in their teacher education programs. In these courses, they cover cognitive theories. As learning takes place, students make sense of the world with their existing schemas and sometimes they resist changing their schemas. So most of the pre-service teachers might look at learning and misconceptions from a cognitivist view of learning and development. Lastly, this theme revealed a code on the perceptions of pre-service teachers about how to address misconceptions once they are diagnosed. Most of the teachers; almost one third of them stated that misconceptions are really difficult to deal with and to build into instruction. The pre-service teachers might not yet feel prepared to work with misconceptions and they only had the idea of correcting misconceptions.

A final note for this theme is that some of the pre-service teachers had difficulty in providing a definition for misconceptions. Misconceptions should be defined as different from simple misunderstandings of a topic or a concept (Gomez-Zweip, 2008). One of the main characteristics of misconceptions that the focus should be on building on these knowledge structures instead of the focus of elimination of them (Stern, 1996) was not stated by any of the pre-service teachers. Some of the pre-service teachers were not aware of the features of misconceptions or they did not know where they fit in the learning and instruction processes.

**Mistakes and Misconceptions**

The findings indicated that the pre-service teachers had difficulty in understanding whether the students made a mistake; provided an incorrect response or had a misconception that hinders learning. One of the pre-service teachers stated*; "If the student has difficulty in solving a problem, in moving along the steps of the problem, this means that this student made a mistake and did not fully comprehend the topic."* For some of the teachers, a student having difficulty in problem solving steps, or answering a question is making a mistake. They tend not to consider a possible misconception. Still most of the teachers believed that frequency is an important indicator of having a misconception and

that a student making a mistake for repeated times points to a misconception. One of them suggested giving chance to students to apply what they learn and making slight changes in the classroom examples can help in differentiating between mistakes and misconceptions.

Students sometimes make mistakes or errors during learning process, which might occur naturally (Ashlock, 2006). Mistakes are generally due to lack of care or attention to the procedure. Students might understand an algorithm but there can be a computational error due to carelessness (Barcellos, 2005; Bush & Karp, 2013). The findings of this theme may address the fact that the pre-service teachers do not have enough experience on how misconceptions have distinguishing features. This might lead to situations where the teachers cannot detect a misconception because they thought that student is making a mistake. This might be related to the insufficient experience they have about defining misconceptions revealed in the previous theme.

**Identifying and Working with Misconceptions**

The pre-service teachers identified and challenged misconceptions of students through six strategies; a) providing additional examples, b) making students active, c) using visuals, d) recovering the topic, e) being attentive about misconceptions prior to instruction, and f) giving real life examples.

Most of the participants; nearly one fourth of pre-service teachers indicated that letting students make explanations helps to determine misconceptions. Following this, approximately one third of them expressed best strategy to address misconceptions was using visual media in the classroom. According to them, using visual materials as diagrams might be helpful in some topics such as comparing the sizes of fractions. One of the pre-service teachers believed that using 3D shapes, and cardboards are effective in addressing misconceptions. Another participant expressed how visuals have great effect in addressing misconceptions and remarked that teachers should be careful as follows: *"Especially in some schools, the classrooms are technologically equipped. However, they should be integrated to instruction with teachers' carefully thinking on ways to address possible misconceptions."*

One eight of the pre-service teachers identified the misconceptions when they gave additional examples. One of the teachers reported: '*I did not realize while teaching content because I do not explain the subject from the very beginning. The student wrote "½ = 2" then I realized the misconception. While I was explaining another concept, I realized it totally accidentally. The student thinks that mathematics is only made up of numbers. I think it was due to lack of previous knowledge. They concentrate on numbers. They [teachers] teach mathematics only over the numbers.*' Another pre-service teacher offered the response; "*The student does not go beyond what is taught in class unless they are exposed to different examples by the teacher…."*

Almost one eight of the participants perceived the importance of explaining topic from very beginning in order to challenge with misconceptions. One of the pre-service teachers who indicated using this strategy stressed; "*When I realize a misconception, I said "forget everything, I am explaining the concept from the beginning"*. This strategy is seen as useful by the pre-service teachers however in the recovering of the topics, they should change the instructional methods or techniques instead of providing exactly the same instruction.

A few pre-service teachers supported the idea that giving real life examples and being attentive to misconceptions while preparing for the lesson might be used as teaching strategies to work on misconceptions. For instance, another teacher explained as *"in probability, for instance, dependent and independent events are confused. We do multiplication in independent event but the children are doing addition. I solved a test to explain and I gave examples…"*. Lastly, 2 of the teachers drew the attention to how science can be connected to real life easily with science journals and scientific news, and that it only requires teachers to make some preparation.

From the findings it might be inferred that most of the pre-service teachers believe that they can identify students' misconceptions by making the topics more concrete by examples than only relying on students' narrative explanations on the topic. Also, findings indicate that using visuals and making students active are common strategies among pre-service teachers to deal with misconceptions. Visual tools and demonstrations can be easily adapted to the lesson so that illogical students thinking which is common in addition of fractions (Chick & Baker, 2005) might be worked on. Recovering the topic and being attentive about misconceptions before instruction takes place emerged as the following least common sub-theme in pre-service teachers' views. Recovering or being attentive about misconceptions such as using cognitive conflict strategy might not be easy for novice teachers. Because re-teaching or recovering the topic requires thinking about what to emphasize and how to teach. Here cognitive conflict can be used as a strategy (Watson, 2002) in which the teachers should provide contradictory situation to them and so the kids can reevaluate their beliefs (Chick & Baker, 2005).

**Sources of Misconceptions**

The participant teachers indicated that misconceptions of the students may stem from a) generalizations made by teachers, b) insufficient examples in instruction, and c) ineffective use of visual and technological materials. Most of the pre-service teachers believed that generalizations made by teachers may lead to misconceptions in students. One of the pre-service teachers who thought like this expressed *"I think misconceptions mainly stem from teachers. They do not explain the concept explicitly. When teachers are making explanation, they generalize."* Lastly another teacher highlighted the fact that especially when the parents are not much attentive to academic progress of the student, the teacher has a larger part in students' learning progression.

Approximately half of the participants supported the role of providing insufficient examples by teachers. According to one of the science pre-service teachers; *"The student should be challenged with more scientific examples. It is important that the teachers have a variety of examples in their repertoire. This makes easier for them to address and improve student thinking"*

Lastly, nearly one fourth of the participants expressed the sources of misconceptions as ineffective usage of visual and technological materials. One of the pre-service science teacher expressed that; "*Once visual materials are used in the classroom, students have more chance to apply and construct their own meaning, and also they can be engaged in group work tasks. And all of these make the class more student-centered, exposing students to think on a deeper level which can have a role in avoiding misconceptions.*"

This theme was observed to focus on the role of the teacher in general. All three of the codes show how the teachers' preparation for instruction and monitoring during instruction can have a role in creating misconceptions.

**Consequences of Misconceptions**

The results showed that the misconceptions might have four main consequences; a) academic underachievement, b) impact on other topics, c) student psychology, and d) classroom management problems.

One third of the participant pre-service teachers agreed that the misconceptions may cause academic underachievement of students. On this issue, one of the pre-service teachers supported her perception by saying "*Firstly it results in underachievement. Low grade decreases students' self-confidence. When new knowledge is learnt, nevertheless the results become negative because of it is constructed on weak basis of prerequisite knowledge. Short-term underachievement…"* Similarly, one third of the pre-service teachers agreed that the students cannot relate one topic to another because of their misconceptions. On the similar case, another teacher stated; *'In long-term, the topic followed by the previous one does not become strong. Topics rely on one another. If he/she (student) continues to add a story on this misconception, the building does not become steady. If it proceeds to be in high school, he/she cannot construct that stable building, in other words cannot construct sound mathematical knowledge.* Some of the other teachers agreed that; "*When the student has a misconception in science at an early grade level, this can affect the high school and college years by having impact on other topics learnt. The teachers should be even more careful about misconceptions especially in early grade levels."*

Nearly one fourth of the participants emphasized the negative effects of misconceptions on student psychology. For example, one teacher told about her experience about having low self-confidence and pessimism toward the topic. She explained; "*The students are getting upset, and descend into mood of*

*pessimism. As if I do not know mathematics... I had that too. I felt it when I attended the university. Why the curve of a parabola is upside…. Reasons: as if memorization is true knowledge. Child would adopt it that he does not want to subvert because it damages his confidence.*"

Two of the teachers had worries about classroom management problems. One of the teachers reported the following: *"According to me, one of the critical things is that once one of the students has a misconception is not addressed well in the classroom, this might affect other students in the class negatively. This will most probably lead classroom management issues. It is like a chain reaction."*

To summarize, prominent findings address the fact that if teachers are more aware of misconceptions of their students, the learners can be more successful in the learning process, their psychology can be improved in a positive way, and more effective tools and strategies can be used during instruction to address and build on misconceptions.

## CONCLUSION

This study investigated the perspectives and experiences of pre-service mathematics and science teachers regarding student misconceptions. It is thought that findings of this study might guide future researches.

The results confirmed some of the existing findings in the literature of misconceptions. The pre-service teachers in this study believe that misconceptions can affect students' learning of other topics in the future (Raven & Kittleson, 2014), and that misconceptions are difficult to address and to build on (Gürel et al., 2015; Özgür, 2013). Paying attention to teachers' distinction between mistakes and misconceptions (Larkin, 2012), and teachers' need to be exposed to more examples on identification of misconceptions (Kılıç, 2011) were some other points that confirmed and extended the existing literature. Some findings were quite different from what the existing literature offered. The pre-service teachers in this study did not talk about the role of textbooks (Tshuma & Sanders, 2015; Gürel & Eryılmaz, 2013), media, peers, and family (Gomez-Zweip, 2008) as the sources of misconceptions. The reason might be that thinking of these factors requires in-service teaching experience. Another point was that the pre-service teachers did not reflect on the role of their own misconceptions. It can be concluded that pre-service teachers need more awareness on their own misconceptions, which might affect their future teaching and eventually student learning.

Another important finding was that pre-service teachers did not mention any possible functions of misconceptions for students. The significance of trying to build on misconceptions was not stated. These did not come out even in the following interview questions asking for functions of misconceptions for students. This may be because the perspective of pre-service teachers focuses

only on negative effects of misconceptions. However, from a constructivist perspective, learner misconceptions can be seen as a resource that can be tapped into for instruction, rather than mistakes to be replaced, or overcome (Larkin, 2012). Pre-service teachers' focus on only elimination on misconceptions and this might prevent them from thinking about what productive functions that misconceptions can have for students' future learning. It can be concluded that pre-service teachers had a limited understanding of the roles and functions of misconceptions. The pre-service teachers might need more experience and practice on how to identify misconceptions and how they can be separated from mistakes. When teachers are skillful in addressing misconceptions, there is great potential in increasing students' conceptual understanding (Holmes, Miedema, Nieuwkoop, & Haugen, 2013). If misconceptions are regarded as mistakes, this can minimize the benefits of incorporating misconceptions effectively to instruction (Larkin, 2012).

In terms of using the appropriate instructional strategies to identify and/or address misconceptions, pre-service teachers did not mention a variety of options. However, they were able to state a few effective methods to deal with misconceptions. Pre-service teachers were aware of only telling the students that they have a misconception cannot be sufficient by itself, and suggested that the teacher needs to work more with the student. This finding is in line with what Chew (2007) recommended in terms of highlighting teachers' role. These results suggested that pre-service teachers needed more training on how to adjust their instruction both to diagnose and to build on misconceptions. This can be linked to another finding of the study, which is that pre-service teachers believed misconceptions are really difficult to challenge and to build into instruction. It might be suggested that due to teachers' limited repertoire of instructional strategies, they believe in the resistance of misconceptions. They might tend to think the implicit learning process is robust which means difficult to change. Therefore, it can be the case that teachers do not believe in the usefulness of efforts to work on misconceptions as they perceive misconceptions as persistent. Misconceptions are sometimes considered as strong barriers to understanding the subject. Even if the teachers intend to use different instructional materials such as text or lecturing, they make no difference. Still, it is a positive outcome that they already had a small repertoire of such strategies and this can be supported in their teacher education programs. Misconceptions do not show themselves in transparent ways only by watching students' behaviors (Hare & Graber, 2000). Teachers should have a large repertoire or proper instructional strategies to determine and work with misconceptions; this will have important contributions to students' learning process. When teachers are attentive and experienced on appropriate instructional methods, they can possess information on students' prior knowledge, misconceptions, and learning difficulties and they can adapt their lesson to a more suitable mode of instruction (Lazarowitz & Lieb, 2006). This will result in teachers' effort of paying attention to misconceptions and work with them in an effective way.

Using multiple representations and/or conceptually related tasks can be suggested. These results are consistent with the findings in that pre-service teachers believe that using visual materials can be effective for probing misconceptions. Their perceptions and experiences are seen as compatible with what some of the related literature reveal (Bair & Rich, 2011; Chick & Baker, 2005; Kidron & Zehavi, 2002). Using shapes and models are also discussed in Turkish context (Biber, Tuna, & Aktaş, 2013; Coştu, Ayas, & Ünal, 2007; Kıcı, 2012; Öksüz, 2010). However, teacher should be aware that using visuals alone is not enough (Navarro & Carreras, 2006), which might contradict with the findings. Besides, being alert on misconceptions of students should be a helpful instructional strategy. In order to gain attention of the students to the lesson before the instruction, teachers can purposefully give an example including contradictory situation. For instance, the teacher can solve the problem or equation in an incorrect way to trigger cognitive conflict of the students. Then the students become alert to principles of the concept. So learners can reevaluate what they already know and reconstruct their own schemata.

The results of the study and of previous researches (Halim & Meerah, 2002; Meyer, 2004) suggest that teachers are not fully prepared to confront science misconceptions when they arise in their classrooms, even if the teachers recognize that such misconceptions exist. Analysis on teacher perspectives and revealing the errors and weaknesses they have can enhance teachers' knowledge of students' thinking (An & Wu, 2012). Pre-service teachers' perceptions about misconceptions and to what extent they are experienced about appropriate strategies are as critical as their misconceptions about certain concepts illustrated in several studies (Aydın & Taşar, 2010; Başarmak & Gelibolu, 2010). In this respect, the results of the study can contribute to improvement of teacher perceptions and experiences on student misconceptions and organization of courses in teacher preparation programs by presenting multiple aspects and recommendations.

As for limitations of the study, the number of the participants is restricted to 11. This limitation could have been overcome during the design of the study by including more number of teachers that could better represented years of experience, experiences in private tutoring. Another limitation might be that the participants are selected from only two public universities in Turkey which can be extended with future studies. As a last limitation, the investigated experiences relied on teachers' self-reports. Although this is highly valuable, it is considered a reflection of teachers' own conclusions. Classroom observations or private tutoring observations can be considered in future research.

**Conclusion with SWOT Analysis**

The findings of this study were further structured into a SWOT analysis framework (Table 3). The SWOT analysis is a structured method to assist the formulation of a strategy. Within scope of this study it helps to identify clearly

what emerged according to the participants' experiences regarding misconceptions (Thomas, Chie, Abraham, Raj, & Beh, 2014).

Table 3. *SWOT Analysis Framework for Pre-service Teachers*

| Strengths | Weaknesses |
|---|---|
| Being aware of possible consequences of misconceptions for teacher, student and classroom environment | Having difficulty in distinguishing mistakes and misconceptions |
| Being aware of some of the effective strategies to address and work with misconceptions | Having a limited repertoire of instructional strategies to address misconceptions |
| Having willingness to learn more about how to build misconceptions into instruction | Being not aware of turning misconceptions into learning opportunities |
| Giving attention to student psychology | |
| Being aware of their role in causing misconceptions as well as addressing and working with misconceptions | |
| **Opportunities** | **Threats** |
| Changes in some of the teacher education courses' content (e.g. teaching methods) focusing more on misconceptions | Teacher education programs might not have the courses that can address how to deal with misconception |
| Pre-service teachers presenting their experiences with their students about misconceptions to their classmates | Not possible to have teaching experience for all pre-service teachers |

In the SWOT analysis framework, the outcomes that are considered as the positive respects within the pre-service teachers' perspectives and experiences are labeled as *strengths*. With these outcomes, pre-service teachers have the chance to improve themselves in learning and practicing more on misconceptions. The outcomes that bring some limitations to pre-service teachers to build on their knowledge and experiences are presented with the section *weaknesses*. Pre-service teachers might continue to hold on to their inaccurate views on misconceptions if not discussed in their teacher education programs. The *opportunities* section in the framework includes the possible changes that can be done that will make it easier to work with pre-service teachers and to help them improve themselves. Finally, possible external factors are presented in the *threats* section. If pre-service teachers do not improve their knowledge and experiences on misconceptions and if they are not exposed to examples and practices in their teacher education programs, these weaknesses might to continue (Bayraktar, 2009).

## IMPLICATIONS

The study provides initial results for mathematics and science pre-service teachers' views on misconceptions. Further research on students' misconceptions in school mathematics and science should empower teachers to use proper strategies to help students build on their misconceptions. Also, the findings suggest focusing on possible negative consequences of misconceptions. In addition to academic underachievement in lessons, effects of misconceptions on students should be taken into consideration. Besides, the relationship between misconceptions and classroom management problems might be explored in detail by observations and working closely with teachers with possible design-based researches. Pre-service teachers' experiences about engaging with student misconceptions in their teacher education programs seemed insufficient to ensure that they will be adequately prepared to address misconceptions with their future students. Courses on misconceptions can be structured with a more practice-based perspective. Lastly, the SWOT analysis framework can be used as a guide for researchers who will study pre-service teachers' perceptions and experiences on misconceptions. The current study exemplified the use of a SWOT analysis as a tool for understanding pre-service science and mathematics teachers' experiences with student misconceptions with regard to their teacher education program. Although SWOT analysis has the limitation of describing individual factors only at a surface level (Yüksel & Dağdeviren, 2007) future research can still use the analysis to reach important findings.

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# GENİŞ ÖZET

## Giriş

Öğrenmeyi etkileyen en önemli faktörlerden birisi de öğrenenin öğrenme sürecine başlamadan önce ne bildiğidir (Ausubel, 1968; Svinicki, 1994). Eğer ön bilgiler güçlü kuramsal temellere dayandırılmazsa, yanlış yorumlamalara yol açmaktadır. Böylece öğrenme üzerinde *kavram yanılgıları*, diğer bir deyişle, naif anlamalar (Badenhorst ve diğerleri, 2015) ya da istenmeyen engeller (Smith, ve diğerleri, 1993) ortaya çıkabilmektedir. Öğretmenler öğrenci fikirlerini belirlemede ve gözlemlemede yetkinse, öğrencinin ön bilgisi ile öğrenilecek bilimsel bilgi arasındaki köprüyü inşa etmeyi daha iyi yapılandırırlar. Deneyimli ya da mesleğe yeni başlamış bir öğretmenin öğrencilerdeki kavram yanılgılarını belirleyebilme yeteneğine sahip olup olmaması bilimsel araştırmalarda incelenmesi gereken önemli bir olgudur. Öğretmen adaylarının kavram yanılgılarını nasıl algıladığı ve deneyimlediği gelecekteki öğrencilerinin öğrenme sürecini geliştirebilmesine yardımcı olmaktadır.

Türkiye'de bu kapsamdaki çalışmalar, kavram yanılgılarının belirlenmesi ve ortadan kaldırılmasına odaklanan öğretim boyutları ile sınırlıdır. Fakat kavram yanılgıları ile nasıl başa çıkıldığı ve kavram yanılgıları üzerine öğretimi tasarlamanın faydalı olduğu vurgulanmaktadır. Öğretmenlerin hataları vurgulayıcı tutumları öğrenme fırsatı olarak görülmektedir (An ve Wu, 2012). Böylece kavram yanılgıları öğretmenler tarafından öğretim süreci ile bağdaşlaştırılarak birer öğrenme kaynağı haline gelmektedir (Smith vd., 1993). Bu bağlamda alan yazınında öğretmenlerin öğrencilerdeki kavram yanılgıları üzerine farkındalıkları, kavram yanılgılarının kaynakları hakkında ne bildikleri ve kavram yanılgıları ile başa çıkabilmek için hangi tür stratejileri kullanabilecekleri üzerine çok az çalışma bulunmaktadır (Fisher, 1985). Öğretmen adaylarının kavram yanılgıları üzerine düşünüşleri hakkında daha fazla araştırma yapılması faydalı görülmekte ve öğretmenlerin henüz kavram yanılgıları hakkında eğitilmedikleri bilinmekte ise de bir kısmı kavram yanılgıları hakkında bilgiye sahiptir ve çoğu ise öğrencilerle ders esnasında pratikte deneyim kazanmaktadırlar (Gomez-Zweip, 2008). Dolayısıyla bu çalışma bu ihtiyaca da işaret etmekte ve cevap bulmaya çalışmaktadır. Çalışmanın hedeflerinden birisi de fen ve matematik eğitiminde öğretmen adaylarının öğrencilerdeki kavram yanılgıları üzerine algı ve deneyimlerini incelemektedir. Öğretmenlerin kavram yanılgıları hakkında bilgi ve deneyimlerini nasıl takip edecekleri konusunda dikkatli olmaları önerilmektedir. Öğretmen adaylarının etkili stratejiler hakkında ne bildiklerini ve deneyimlediklerini araştırmak da bu çalışmanın kapsamı arasında yer almaktadır. Yukarıda belirtilen alan yazını ışığında, öğretmen adaylarının kavram yanılgılarına ilişkin algı ve deneyimlerini ortaya koyabilmek için aşağıdaki araştırma sorularına yanıt aranmıştır:

a) Fen ve matematik öğretmen adaylarının kavram yanılgılarına ilişkin algıları nelerdir?

b) Fen ve matematik öğretmen adayları kavram yanılgılarına ilişkin öğretim stratejileri üzerine ne derece deneyime sahiptir?

**Yöntem**

Öğretmen adaylarının algı ve deneyimlerini derinlemesine ortaya koyabilmek için nitel araştırma deseni kullanılmıştır (Patton, 2002; Seggie ve Bayyurt, 2015). Çalışma Türkiye'deki iki devlet üniversitesinde, 6 fen ve 5 matematik olmak üzere toplam 11 katılımcı ile yürütülmüştür (10 kadın, 1 erkek). Katılımcılar ölçüt örnekleme yöntemine göre seçilmiş olup (Fraenkel, Wallen, ve Hyun, 2012; Seggie ve Akbulut-Yıldırmış, 2015, p.26), fen ve matematik öğretmeni adaylarının ortaokul öğrencileri ile öğretim deneyimine sahip olmaları kıstas olarak alınmıştır. Öğretmen adaylarının hepsi özel eğitim merkezlerinde (dershane) birebir öğretim deneyimine sahiplerdir. Öğretmen adaylarının 2 ile 6 yıl arasında 3. sınıf (n=3) ve 4. sınıf öğrencileri (n=8) ile öğretim deneyimi bulunmaktadır. Katılımcıların çoğu öğrencilerle çalışmadan önce kendi ders planlarını kendilerinin tasarladığını belirtmiştir (n= 6). Çalışmanın verileri araştırmacılar tarafından hazırlanan geçerliği ve güvenirliği sağlanmış görüşme sorularını içeren yarı yapılandırılmış görüşmelerle toplanmıştır (Yıldırım ve Şimşek, 2013). Görüşme formu 11 sorudan ve 2 bölümden oluşmaktadır: 1) demografik bilgi soruları, 2) algı ve deneyimleri belirlemeye yönelik sorular. Görüşme sorularına Türkiye'de yer alan özel ve devlet üniversitelerinde çalışmakta olan 4 araştırma görevlisinden uzman görüşü alınarak son şekli verilmiştir. Tüm görüşmeler Türkçe gerçekleştirilmiş olup daha sonra çalışma kapsamında analiz edilmek üzere İngilizce' ye çevrilmiştir. Veriler toplandıktan sonra nitel veri analizine uygun olarak içerik analizi 4 aşamada gerçekleştirilmiştir (Strauss ve Corbin, 1990; Kızıltepe, 2015): 1) verilerin kodlanması, 2) temaların belirlenmesi, 3) kodların ve temaların sıralanması, 4) bulguların belirlenmesi ve yorumlanması. Analizlerin sonucunda da çalışma kapsamında 5 tema ve bu temalar altında 16 kod ortaya çıkarılmıştır.

**Bulgular**

Araştırma bulguları 5 tema altında toplanmıştır: (1) kavram yanılgısının tanımı ve doğası, (2) kavram yanılgısı ve hata, (3) kavram yanılgısını belirlemek ve üzerinde çalışmak, (4) kavram yanılgısının kaynakları ve (5) kavram yanılgısının sonuçları. Veri analizleri sonucu ortaya konan bu temalar sonuç ve tartışma bölümlerinin de organize edilmesinde yol göstermiştir.

Kavram yanılgılarını tanımlama noktasında öğretmen adaylarının zorlandıkları görülmüştür. Kavram yanılgılarını tanımlarken var olan bilgi ve düşünüş biçimini ortadan kaldırmak yerine kavram yanılgısı üzerinde çalışmak noktası (Stern, 1996) katılımcıların ifadeleri arasında yer almamıştır. Pek çok öğretmen adayının kavram yanılgılarının özellikleri ve öğrenme süreçlerindeki rolü ile ilgili farkındalığa sahip olmadıkları söylenebilir. Kavram yanılgılarının hatalardan ayırt edici özellikleri noktasında da katılımcıların bilgi ve deneyim eksikliği gözlenmiştir. Öğretmen adaylarının kavram yanılgılarını belirlemek ve üzerinde çalışmak için sahip oldukları stratejiler şunlardır: öğrencinin aktif

olduğu eğitim ortamı, görsel kullanımı, konunun tekrar üzerinden geçirilmesi, öğretim öncesi ders planında kavram yanılgısının ihmal edilmemesi, ve gerçek hayattan örnekler kullanılması. Öğretmen adayları kavram yanılgılarının kaynakları olarak ortaya konan kodlarda öğretmenin rolüne işaret etmişlerdir. Öğretmenin yaptığı genellemeler, öğretimde yeterli örnek kullanılmaması ve görsel ve teknolojik araçların etkin kullanılmaması katılımcıların belirttikleri kavram yanılgısı kaynaklarıdır. Son olarak kavram yanılgılarının sonuçlarını akademik başarısızlık, diğer konuları etkileme, öğrenci psikolojisini olumsuz etkileme ve sınıf yönetimi problemi olarak görmektedirler.

**Sonuç ve Tartışma**

Öğretmen adaylarının algı ve deneyimlerine göre alanyazın ile tutarlı olan ve alanyazına farklı çerçeveden bir bakış sağlayacak sonuçlar ortaya konmuştur. Kavram yanılgılarının öğrencilerin diğer konuları öğrenmelerini olumsuz etkilemesi (Raven ve Kittleson, 2014), kavram yanılgılarının tespit edilme ve üzerinde çalışmanın zor olduğu (Gürel, Eryılmaz, ve McDermott, 2015) öğretmen adaylarına daha fazla örnek gösterilmesinin gerekliliği (Kılıç, 2011) alanyazını destekler niteliktedir. Öğretmen adaylarının ders kitapları (Tshuma ve Sanders, 2015), medya araçları, aile (Gomez-Zweip, 2008) gibi kaynakların kavram yanılgısı oluşturmadaki rolünden söz etmemeleri alanyazından farklı bulgular olarak dikkat çekmiştir. Kavram yanılgılarını tespit etme ve üzerinde çalışmaya dayalı öğretim stratejileri noktasında katılımcıların ufak da olsa bir repertuarları olduğu görülmüştür. Ancak daha çeşitli ve etkin stratejilerle kendilerini donatmaları gerekliliği öne çıkmaktadır. Öğretmen adaylarının kavram yanılgılarının sonuçları ve kaynakları noktasında farkındalık sahibi olmaları ve kendi rollerinin önemini bilmeleri önemli bulunmuştur. Çalışma sonuçları son olarak bir SWOT Analizi (Thomas ve diğerleri, 2014) ile geliştirilerek sunulmuştur. Bu analiz ile amaç öğretmen adaylarının algı ve deneyimlerini iyi bir organizasyon ile ortaya koyarak gelecekteki çalışmalara ışık tutmaktır.

Öğretmenlerin algı ve deneyimlerinin ortaya konması onların geliştirilebilir yönlerine işaret etmektedir. Çalışma sonuçlarının öğretmen eğitiminde alınan ders içeriklerine sunulan farklı bakış açıları ve sonuçlarla katkı sağlanması hedeflenmektedir.