ORIGINAL ARTICLE

Turkish Pre-Service Teachers' Perceptions of Factors Influencing Physics Problem-Solving Abilities

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Abstract: *The purpose of this study was to identify the the factors that influenced pre-service teachers' perceptions of their abilities to solve structured physics problems. 1185 pre-service teachers from different disciplines, enrolled in physics courses in one Turkish University from 2008 to 2017 participated in a descriptive survey. The factors influencing the pre-service r physics problem-solving abilities, ranking from most to least, were as follows: personal characteristics; quality of secondary or university physics teaching; secondary school physics education, and physics learning environment. The study implies the need for: (i) equal opportunities; (ii) knowledge integration; and (iii) learning affordances, which are relevant not only to Turkey but also to worldwide physics education.*

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Introduction

A SIGNIFICANT goal of physics education is to equip students with problem-solving skills, which is one of the 21st-century skills (Docktor et al., 2015; Hsu et al., 2004; Trilling & Fadel, 2009). Some researchers claim that students can learn the physics concepts while doing practical physics problems (Freitas et al., 2004; Gök, 2014; Johnson, 2001; Sing, 2009). That is while solving physics problems, students can develop a conceptual understanding of a physics phenomenon and related mathematics knowledge (Docktor et al., 2015). However, if the pre-service teachers are deficient conceptual understanding of a particular physics phenomenon and related ding mathematical knowledge, they will be unable to analyze the given physics problem (Ogünleye, 2009).

Problem-solving involves defining the underlying concepts/principles, analyzing procedures, as well as evaluating and interpreting the solution. However, understanding the fundamental laws and theories of physics does not guarantee that students are able to organize the related facts around the physics problems to solve them (Gök, 2014). Because most of the physics problems can be solved using several methods (Haratua & Sirait, 2016, Jonassen, 2011), students need to qualitatively analyze them, e.g., sketching, restating the problem with their words, and reviewing/revising relevant equations or theorems (Gustafsson et al., 2015).

Too often teachers solve physics problems procedurally that only requires physics and mathematics knowledge to assess students' knowledge (Örnek, 2009). Therefore, students' physics problem-solving skills remain very limited or even poor after an advanced undergraduate course (Gerace & Beatty, 2005). For this reason, traditional teacher-cantered problem-solving method-is a factor influencing students' physics problem-solving skills (Docktor et al., 2015; Gök, 2014; Freitas et al., 2004). However, developing students' physics problem-solving skills require physics teachers, for instance, helping them to make predictions and interpretations by drawing relationships between their prior and new knowledge (Hohensee, 2016), which they generally tend to neglect (Soylu & Soylu, 2006). Teachers' inability or the lack of competency to connect students' prior knowledge to physics problem-solving deters skill development (Carrier, 2013; Hohensee, 2016; Soylu & Soylu, 2006).

Literature Review

Earlier studies pertaining to physics problem-solving have had several foci; beliefs (Mistades, 2007), attitudes (Balta et al., 2016; Erdemir, 2009; Good et al., 2019), achievement (Ghavami, 2003; Taşoğlu, 2009), conceptual understanding (Ergün, 2010), instructional strategies (Good et al., 2019; Gök, 2012), learning (Şahin & Yörek, 2009), assessment (Docktor et al., 2015; Gök, 2014) physics teachers' problem-solving difficulties (Ogünleye, 2009), teachers' conceptions and practices of physics problem-solving (Asikainen & Hirvonen, 2010; Freitas et al., 2004), teachers' views of different physics teaching approaches (Mulhall, 2005), and the differences between the expert and novice problem solvers (Kohl & Finkelstein, 2008). However, none of them has investigated pre-service teachers' self-perceptions of the factors influencing problem-solving skills over years.

Previous studies have focused on varied factors of undergraduate physics students' learning and/or approaches: for example, teacher-related epistemological factors (Karatas & Erden, 2017; Kingsley, 2011; Lin et al., 2013; Stathopoulou & Vosniadou, 2007), students' and experts' metacognition (Gašević et al., 2015; Jonassen et al., 2003), students' epistemological beliefs (Elby, 2001; Fletcher & Luft, 2011), students' attitudes and beliefs about learning physics and the structure of physics knowledge (Erdemir & Bakırcı, 2009; Guido, 2018; Shin et al., 2003), students' expectations of physics teaching (Marshall & Linder, 2005) and students' difficulties/inabilities/misunderstanding of problem-solving strategies (Gök, 2011; Gök & Sılay, 2009; Pol et al, 2005). Further, some studies, which have challenged students' problem-solving skills, have suggested student-centered instructional practices for problem-solving (Ali, 2019; Saka, 2011; Çalıskan & Selçuk, 2010; Gök, 2012). Moreover, there have also been few comparative studies that handle different features/factors, e.g., grade, science background (Al-Omari & Miqdadi, 2014; Kırılmazkaya, 2010).

When the article is examined, we have observed that many studies have been conducted on physics pre-service teachers and on the solution of physics problems. We have seen that studies on the learning approaches of physics pre-service teachers are generally carried out by taking into account the focal points such as epistemological factors-beliefs (Elby, 2001; Fletcher & Luft, 2011; Karatas & Erden, 2017; Kingsley, 2011; Lin et al., 2013; Stathopoulou & Vosniadou, 2007), metacognition (Gašević et al, 2015; Jonassen et al., 2003), attitude towards physics learning (Erdemir & Bakırcı, 2009; Guido, 2018; Shin et al., 2003), expectations from physics teaching (Marshall & Linder, 2005) and problem solving strategies (Gök, 2011; Gök & Sılay, 2009; Pol et al., 2005).However, when the studies on the solution of physics problems are examined, we have observed that these studies are generally carried out by taking into consideration the fundamentals such as achievement (Ghavami, 2003; Taşoğlu, 2009), beliefs (Mistades, 2007), attitudes (Balta et al., 2016; Erdemir, 2009; Good et al., 2019), conceptual understanding (Ergün, 2010), teaching strategies (Good et al., 2019; Gök, 2012), learning (Şahin & Yörek, 2009) and evaluation (Docktor et al., 2015; Gök, 2014). In addition, we have seen that there are studies based on difficulties in problem solving (Ogünleye, 2009), problem solving understandings and practices (Asikainen & Hirvonen, 2010; Freitas et al., 2004), views on physics teaching approaches (Mulhall, 2005), and the differences between expert and novice problem solvers (Kohl & Finkelstein, 2008). This situation highlights that there are no studies examining physics pre-service teachers' self-perceptions about the factors affecting their problem-solving skills. Furthermore, there has been no long-term systematic documentation of pre-service teachers' self-perceptions of the factors that affect problem-solving. We identified this neglected area in relation to the pre-service teachers' perceptions of the factors influencing their physics problem-solving abilities. By doing this, the current study purposes to elicit influential factors that need to be handled within teacher preparation programmes. Thus, this study will provide insights into preparing better physics teachers in problem-solving so that they can confidently teach their physics students so that their achievement will improve. When pre-service teachers are conscious about developing students' physics problem-solving skills, they will take an active role in learning those competencies. This study will enrich problem-solving literature and fill in the apparent gaps. Therefore, this study aimed to identify pre-service teachers' self-perceptions of the factors that impact their physics problem-solving skills. For these reasons, the following research question framed this study:

What are pre-service teachers' self-perceptions of the factors (h that affect physics problem-solving skills?

Theoretical Framework

Even though several behavioral psychologists or cognitive theorists have strived to explain problem-solving processes (Anderson, 1987; Docktor, 2009; Docktor & Heller, 2009; Ormrod, 2004), all of them concur that problem-solving involves complex skills (Adams & Wieman, 2015; Csapó & Funke, 2017). Those skills include understanding the problem, thinking of possible solutions, elaborating the problem, solving the problem, and revising the problem solving (e.g., Adams & Wieman, 2015; Bassok & Novick, 2012; Dinica et al., 2014; Van Gog et al., 2005). Therefore, understanding the problem-solving plays a significant role in improving problem-solving skills (Treffinger et al., 2008). Similarly, experience has a pivotal role at handling, make a decision and take an action to solve a problem. For example, previous research has reported that experienced and inexperienced problem solvers revealed variations in retrieving relevant physics information/knowledge from long-term memory and processing time for solving physics problems (Canham & Hegarty, 2010; Tai et al., 2006; Tsai et al., 2012). In other words, these studies emphasized that experienced problem solvers followed a hierarchical process based on physics rules, principle-based approaches, and metacognitive strategies to arrive at logical solutions

(Friege & Lind, 2006; Ince, 2018; Taasoobshirazi & Farley, 2013). Physics educators, who have adjusted and/or adapted these problem-solving techniques suggested by behaviorial and cognitive researchers, have offered some problem-solving frameworks for physics teaching (Heller & Heller, 2000; Lin & Singh, 2013; Malone, 2008; Reddy & Panacharoensawad, 2017; Singh, 2008). These frameworks generally contain stages of problem-solving to make the complex physics problem-solving clear. These stages of problem-solving elicit a variety of representations or problem (Byu & Lee, 2014; Niss, 2012; Taasoobshirazi & Ferley, 2013; Williams, 2018). For this reason, exploring pre-service teachers' self-perceptions of the factors that influence physics problem-solving skills may give insight about their problem-solving variations.

Methodology

Description of University

The participating Physics pre-service teachers come from a Turkish University located in northern Turkey. The northern university consists of 50000 students with almost 5,000 in education. This university has an elementary and a secondary education program that takes four years with the nearly same core courses in the faculty of education. Pre-service teachers participating in this study were enrolled in the following departments and programs: Math and Science Education (Physics Teaching Program, Science Education Program), Elementary Education (Elementary Education Program), and Computer and Instructional Technology Education (Computer and Instructional Technology Education Program). Students in these program areas take two semesters of fundamental physics in the faculty of education together with methods courses. In contrast, secondary physics pre-service teachers also participated in this study. They come from the department of Math and Science Education from two different backgrounds. The first one is the physics education program at the time of the study was five years long. After 2016, the secondary education program was shortened to four years same as the other programs mentioned above. The physics pre-service teachers spend the first three and half years taking physics courses in the physics department of the faculty of science. In the first-year program, students take two semesters of fundamental physics courses and other physics courses. Upon completing the physics courses, the physics pre-service teachers take one and a half-year of methods of teaching and learning physics in the faculty of education. The second group of pre-service teachers is from the Department of Physics in the Faculty of Science. Students in this program also take two semesters in the first year of fundamental physics in the faculty of science together with other physics courses. When they graduate from the Department of Physics in the Faculty of Science, they could pursue the physics teacher certificate program as physics pre-service teachers.

Description of Physics Course and the Nature of Teaching

Physics pre-service teachers take traditional physics courses in the Department of Physics in the Faculty of Science. Whereas pre-service teachers from the departments of Elementary Education, Science and Technology Education, and Computer and Instructional Technology Education take Physics-I and Physics-II in the Faculty of Education. Both programs in the two terms of the first year take four theoretical credits without application. These courses are prescriptive and structured. These courses are offered two times per week for 15 weeks. Each week the instruction is four hours long. The enrolment in the two physics courses is about 45 students each. The lectures are given in theatre-type halls where seats are in circular rows.

Both groups of pre-service teachers are taught through lectures and they copy notes from the chalkboard. For homework they are assigned about 10 physics problems found at the end of each chapter. When the class meets again the pre-service teachers voluntarily or when called by name come to the board and work through the problem with the assistance of the instructor. Other pre-service teachers in class concurrently check their work based on the student's work on the board. At times, pre-service teachers are assigned problems to be solved in class and they work through these problems in small groups. At the end of the term, as a means of preparing for the final examination, pre-service teachers are assigned many physics problems.

Research Design

This research adopted a descriptive survey design. Descriptive research is the type of research, which tries to define the event or events people come through, without interpretation and as it is. The data gathering method of this research type focuses on discovering the specific events (Lambert & Lambert, 2012).

Participants

The participating pre-service teachers, prior to admission to the university identified in this study, have studied in one of the eight different types of high schools, namely, Anatolian High School, Private High School, Science High School, Classical High School, Vocational High School, Imam Hatip

Table 1. Description of the School Types.

School Type	Definition
Anatolian High School	The aims of Anatolian High School; to prepare students for higher education programs according to the interests, abilities and achievements of the students, to learn at a level that can follow the foreign languages and scientific and technological developments in the world. The average exam scores of Anatolian High Schools are between 450 and 500, and the rate of graduates to settle in universities is high (URL1)
Private High School	Turkey opened paid in secondary educational institutions are opened various types of secondary schools by the Ministry of Education (URL2).
Science High School	Students with high skills in science and mathematics prepare higher education in the field of mathematics and science. It is the foundation for the training of highly qualified scientists in the areas of mathematics and science (URL3).
Classical High School	Classical high schools are institutions that provide education and education for the middle and high school or imam-hatip middle school with four years of education and / or daytime education. These institutions aim to prepare students for tertiary education, profession, life and business by giving them a common general culture at secondary level (URL4).
Vocational High School	It is aimed at educating the human power in accordance with the national and international occupational standards required in business, service and health fields (URL5).
Imam Hatip High School	It is the secondary education institutions which are in the secondary education system opened by the Ministry of National Education to prepare both vocational and tertiary education in order to train the personnel in charge of İmamlık, Oratory and Kur'an Course Teaching (URL6).
Super High School	These high school-type Anatolian High Schools cannot meet the demand for intensive students as a result; they are established as an alternative for similar purposes (Ergüder, 2005).
Anatolian Teacher Training High School	Anatolian teachers are high school students aiming to prepare students for higher education institutions that educate teachers, to instill the spirit of teaching to the students, to give the behaviors required by the teaching profession and to give a common culture to all the students at the secondary education level (MEB, 1992).

Table 2. Categories of High Schools.

Category of High School	School
1	Classical High School
2	Super High School
3	Anatolian High School, Private High School, Science High School
4	Anatolian Teacher Training High School
5	Vocational High School -Imam Hatip High School

High School, Super High School, and Anatolian Teacher Training High School. The description of school types is represented in **Table 1**. Each of these schools has different academic standing. For example, Science High Schools are the highest academic status.

Table 2 represents similar academic schools that are grouped together because of the smaller number of research participants that represent each type of school.

Table 3. Research Sample for Pre-Service Teachers.

University	Year	Department				
		Physics Edu.	Physics Teac. Cert.	Sci. Edu.	Element. Edu.	Comp. & Ins. Tech.
Trabzon University (N=1,185)	2008-2009	30	20	30	30	25
	2009-2010	30	20	30	30	25
	2010-2011	30	20	30	30	25
	2011-2012	30	20	30	30	20
	2012-2013	30	35	30	30	20
	2013-2014	25	35	30	30	20
	2014-2015	20	35	30	30	20
	2015-2016	15	30	30	30	20
	2016-2017	10	15	30	30	20

Those who successfully complete high school and wish to do higher studies enter a university, based on their Higher Education Entrance Examination (HEEE) grades. A percentage of students who have secured average scores in the HEEE are admitted to the universities identified in this study. It means universities enrol students from different parts of the country as well as local students because of their home base and family ties.

Participants in the study consisted of 1,185 pre-service teachers from different disciplines enrolled in physics courses in the Northern University during 2008-2017. The total number of participants is composed of 220 pre-service teachers from Physics Teaching Program, 230 from Physics Teacher Certificate Program, 270 from Elementary Education, 270 from Science Education, and 195 from Computer and Instructional Technology Education. **Table 3** represents pre-service teachers' university, years they took to complete the program, each type of department, and undergraduate programs. Because participants take physics course in the same context as the first year of different undergraduate programs, data analysis is the same.

Development of Survey Instrument

The five-point Likert-type scales (Never-1, Seldom-2, Sometimes-3, Often-4, and Always-5) survey instrument originally consisted of 25 items. The survey items were validated by eight science teacher educators. The instrument was first pilot tested with 200 pre-service teachers who did not take part in this study. From each of the departments stated above, 75 pre-service teachers were randomly selected. These pre-service teachers were requested to specify their perceptions of those factors that impact their physics problem-solving abilities. The influential factors were then categorized, and the fre-

Table 4. Pre-Service Teachers' Perceptions of Factors Influencing Their Physics Problem-Solving Abilities According to School Types.

	Sum of Squares	df	Mean Square	F	p
Between groups	3943.66	4	1067.37	7.11	0.000
Within groups	173748.62	1179	108.45		
Total	178412.35	1184			

Table 5. Variation of Pre-Service Teachers' Perceptions of Physics Problem-Solving Abilities According to School-Type.

HS	HSC	N	α=0.05: 1	α=0.05: 2
APS	3	305	3.11	
CL	1	323	3.13	3.13
VIH	5	144	3.22	3.22
SU	2	228	3.29	3.29
ATT	4	185		3.33

HSC	1				2				3				4				5			
HSC	2	3	4	5	1	3	4	5	1	2	4	5	1	2	3	5	1	2	3	4
MD	-0.154	0.016	-0.184	-0.107	0.154	0.184	-0.017	0.050	-0.016	-0.184	-0.219	-0.134	-0.184	0.017	0.219	0.081	0.107	-0.050	0.134	-0.081
p	0.005	0.978	0.028	0.712	0.005	0.006	0.987	0.973	0.978	0.006	0.013	0.551	0.028	0.987	0.013	0.932	0.712	.0973	0.551	0.932

MD: Mean Difference; HS: High School; HSC: High School Category. APS: Anatolian, Private, Science; VIH: Vocational, Imam Hatip; ATT: Anatolian Teacher Training; CL: Classical; SU: Super.

quency tabulated. Based on item analysis, four questions were dropped. Finally, the survey questionnaire consisting of 21 items (See Appendix) was administered to 1185 pre-service teachers in the study. The reliability coefficient (Cronbach alpha) of the instrument, based on the SPSS 27.0 program, was found to be 0.825. After gathering survey data from the pre-service teachers; they were presented to the participants for to establish consistency. Then, the survey data were categorized based on shared philosophy or approaches of the pre-service teachers that reflect the meaningful outcomes of the survey.

Analysis of Data

The survey data were analyzed with SPSS 27.0 using standard deviation, mean (see Appendix), t-test, and one-way variance (ANOVA).

Results

To identify the pre-service teachers' perceptions of those factors that influenced their physics problems-solving with respect to the type of schools, ANOVA analysis was conducted (see **Table 4**).

The data analysis related to variance of pre-service teachers' perceptions of factors influencing physics problem-solving abilities according to the type of school, a significant difference was found at the level of $p = 0.000 < 0.05$ (see **Table 4**). To find out the origin of this difference, Tukey-b and Post-Hoc Tests were conducted (see **Table 5**).

Table 5 depicts a difference between the pre-service teachers graduating from Anatolian High School, Private High School, Science High School and Super High School and Anatolian Teacher Training High School concerning their perceptions of factors influencing physics problem-solving abilities. Compared to the pre-service teachers graduating from Anatolian High School, Private High School, and Science High School, physics problem-solving abilities of those who graduated from Super High School and Anatolian Teacher Training High School were better. Also, there is a significant difference between the graduates of Classical High School and Super High School and Anatolian Teacher Training High School with respect to the pre-service teachers' perceptions of factors influencing their performance in physics problem-solving. Pre-service teachers graduating from Super High School and Anatolian Teacher Training High School indicated better abilities in physics problem-solving than the graduates of Classical High School. To show pre-service teachers' perceptions of the factors influencing their physics problems-solving based on their undergraduate program, ANOVA analysis was utilized (see **Table 6**).

To show pre-service teachers' perceptions of the factors influencing their physics problem-solving abilities based on their undergraduate program, an ANOVA analysis was utilized (see **Table 6**). The results show no statistical difference ($p = 0.4\ 3> 0.05$, $F = 0.879$) based on the undergraduate program they had attended. In terms of gender, there was also no statistical difference ($XF = 3.18$, $XM = 3.15$, $t = 1.02$, $p = 0.31 > 0.05$, $F = 2.76$). It is indicated that there is not a meaningful difference between undergraduate programs included physics courses in the faculty of education such as science teacher, physics teaching, physics teacher certificate, elementary education, computer, and instructional technology education with respect to pre-service teachers' perceptions of the factors influencing their physics problem-solving abilities based on their undergraduate program.

Based on the findings of the survey, the pre-service teachers' perceptions of main factors influencing their physics problem-solving were indicated sequentially from biggest to smallest one as follows: the secondary and university teachers' ability to make the physics courses likeable, enjoyable,

Table 6. Variation of the Pre-Service Teachers' Perceptions of Physics Problem-Solving Abilities Based on the Undergraduate Program.

	Sum of squares	df	Mean square	F	p
Between groups	0.96	3	0.321	0.879	0.43
Within groups	356.72	1181	0.343		
Total	357.68	1184			

Table 7. Mean Values of Pre-Service Teachers' Perceptions of the Factors Influencing Their Physics Problem-Solving Abilities.

Categories of Factors Influencing	Supporting Examples	Mean
Pre-service Teacher Characteristics	Difficulty in performing mathematical operations	2.44
	Poor study habits	2.76
	Lack of basic geometry knowledge to learn physics	2.91
	Negative disposition to physics learning	3.05
	The inability to translate theoretical ideas into practice	3.24
	Lack of physics knowledge at a proficient level	3.30
	Difficulty in converting scientific units	3.33
Quality of Secondary or University Physics Teaching	Excessive use of formulas and mathematical operations	3.23
	Insufficient use of teacher-centered methods and prevalent use of traditional methods and techniques for physics learning	3.61
	Ineffective board use in physics teaching	3.35
	Physics course offering that has no value to everyday life	3.63
	Absence of group works and the activities	3.25
	Insufficient use of examples in physics problem-solving	3.42
Secondary School Physics Education	Not enough weekly course hours for physics in secondary education	2.77
	No physics course offered or physics taught by non-disciplinary teachers	3.21
	Conditioning only to obtain test results at the private courses.	3.15
	Insufficiency of pre-university physics teaching	3.39
	Multiple-Choice Questions in University Entrance Physics Examination	3.62
Physics Learning Environment	Classroom physical structure and facilities	3.45
	Living insufficient conditions to study effectively	2.87
	Crowded classrooms	3.15

and valuable to their lives (3.63); focusing merely on the discriminators of the multiple-choice type HEEE ignoring the problem-solving procedure (3.62); the secondary and university teachers' capability of using appropriate methods and techniques of teaching (3.61); a lack of necessary materials needed for physics courses (3.47); inappropriate examples used in class (3.42); pre-university physics education (3.39); teachers' insufficient use of board (3.35); lack of knowledge of basic physics measurement units and difficulty in converting one form into another (3.33); and lack of physics content knowledge (3.30) are among the primary reasons for inabilities in solving physics problems (see Appendix for the survey). In addition, the pre-service teachers' perceptions of factors influencing their physics problem-solving according to the survey findings have been grouped in **Table7**.

Table 7 depicts that pre-service teachers' perceptions of factors influencing their performance in physics problem-solving enumerated from the most influential to the least are as follows: pre-service teachers' characteristics (21.03), quality of secondary or university physics teaching (20.49), secondary school physics education (16.14), and physics learning environment (9.47).

Discussion

Compared to the pre-service teachers who graduated as high school students from Anatolian High School, Private High School, and Science High School, the ability to understand and solve physics problems by those graduated from Super High School and Anatolian Teacher Training High School is superior (see **Tables 2** and **4**). In the research, which was carried out by Yıldırım et al. (2011), it was pointed out that the problem-solving perception of Science High Schools is higher than those on Anatolian and General High Schools. This could be explained because the education program of science high schools includes more lesson hours of physics and science in the weekly lesson program. By this way, students who take education in the science high schools can get higher level of interaction with physics problems than other types of schools' students (Berberoğlu & Kalender, 2005).

Tables 2 and **4** also reveal that pre-service teacher as high school students who graduated from Super High School and Anatolian Teacher Training High School can solve physics problems at a higher level than those of Classical High School. As for the research which was carried out by Korkut (2002), it is concluded that there is no effect of having an education from Super or General high schools on students' problem-solving skills. Since problem-solving is an inquiring task, the students find out the solution pathway to reach course objectives from problem situations or given information (Docktor et al., 2015; Dinica et al., 2014). In addition to this, the solving problem is one of the main tools for teaching physics, and it is the main part to manage the scientific goals of explaining, predicting, or elaborating (Malinovschi, 2003). Thus, when students have ability in relation to the problem-solving skills, the physics teaching process could contribute to the students for reaching course objectives at the expected level. In this case, teachers able to have reached their students' physics curriculum target. This is because of the effect of the curriculum implemented in Super High School and Anatolian Teacher Training High School, and the fact that the pre-service teachers were channelled more efficiently than those from the other types of high schools. As well, students who graduated from Anatolian Teacher Training High School are more conscious about their secondary education than other schools with respect to school aims and culture, which are highly influenced by the Turkey Ministry of National Education (TMNE).

Table 6 shows that there is no meaningful difference between the reasons for their inabilities in problem-solving with respect to the under-graduate program and their gender. The developmental level of problem-solving abilities in physics does not vary among the pre-service teachers according to the undergraduate program they followed and their gender. There is no meaningful difference between physics pre-service teachers and others. Similarly, it is underlined that gender/sex does not affect problem-solving skills in the research carried out by Çilingir (2006), Gültekin (2006), Özkütük et al. (2003), Tümkaya and Iflazoğlu (1999). Unlike the previous research, it is pointed out that female student's problem-solving skills are higher than male students in the research of Ferah (2000), Katkat and Mızrak (2003), Serin and Derin (2008) and Yıldırım and colleagues (2011), yet the research of Korkut (2002) and Koray and Azar (2008) male students' problem-solving skills found higher than female students. However, it can be expected that pre-service teachers who participate in physics courses could develop more physics problem-solving abilities compared with other pre-service teachers from other programs such as science, elementary, and computer and instructional technology. The absence of meaningful difference between the two previous groups suggests that pre-service teachers who participate in physics courses are not paying serious attention to learn how to solve physics problems.

Our study results showed that there was no gender difference in pre-service teachers' perceptions of problem-solving abilities. However, Şahin and Yörek (2009) indicate that there is a gender difference in students' beliefs regarding learning physics, participating in physics activities, and working to make sense of physics. In contrast to the results of our study, Neber et al. (2008) indicated that high school male students are more active and willing to use problem-solving abilities compared to the counterpart female students. However, in line with our study Çalışkan and Selçuk (2010) found no significant difference in relation to using self-regulation problem-solving strategies between female and male pre-service teachers. Pre-service teachers' perceptions of factors influencing their performance in physics problem-solving is based on the following reasons: the pre-service teachers' characteristics (21,03); quality of secondary or university physics teaching (20.49); secondary school physics education (16.14); and physics learning environment (9.47) (**Table 7**). With respect to pre-service teachers' characteristics, the pre-service teachers identified that they could not perform mathematical skills such as four operators, integrals, and derivatives and recognized that they were deficient in three-dimensional or visual thinking. They also stated that insufficient math skills led to poor understanding of physics concepts. They admitted that they could not understand what the physics problem is asking for and the main points of the question. Pre-service teachers also recognized their lack of theoretical knowledge and ability to correlate problem data with related physics principles as well as their difficulty in unit conversion. These self-identified factors could definitely weaken physics problem-solving abilities. Aligned with pre-service teachers' perceptions, Mathan and Koedinger (2005) emphasize that when students do not have enough content knowledge, they are not proficient in problem-solving. Furthermore, Mulhall (2005) points out that the importance of mathematics in teaching and learning physics is often regarded as the "language of physics". For this reason, the pre-service teachers ought to be good at mathematics to understand physics ideas. Pre-service teachers discussed their attitudes towards learning physics. Desoete et al. (2004) clearly state believing in oneself has a relationship with the ability to reason practical tasks such as physics problem-solving (Hammer, 1994). Pre-service teachers perceived the quality of secondary or university physic teaching as a major factoring influencing their physics problem-solving performance. As pre-service teachers have pointed out, teachers' educational strategies are crucially essential, especially using appropriate materials and activities relevant to the subject matter (Karamustafaoğlu, 2006).

The results of this study concur with the statement of Mulhall (2005) and Ogünleye (2009), who state that there is a strong correlation between physics teachers' poor ability to understanding the subject matter and the ability to provide guidelines to students on how to solve physics problems. Park and Lee (2004) point out that students, high school physics teachers, and university physics educators do not have sufficient knowledge to relate to everyday applications of physics problem-solving, and thus, might have a negative influence on solving physics problems. Students taking physics courses who do not realize they might be potential pre-service teachers and eventually school teachers also affect how they learn and what they want to learn (Mitchell & Carbone, 2011; Mulhall & Gunstone, 2012; Şahin & Yörek, 2009). Some students assume that physics is not connected to the real world; others perceive those ideas learned in physics have strong and useful relationships with a variety of real contexts (Mistades, 2007). Such mixed attitudes toward physics learning either negatively or positively affect pre-service teachers' problem-solving abilities at higher levels.

In relation to secondary school physics education conducted at the secondary education level, most pre-service teachers emphasized that they had studied physics superficially to pass the multiple-choice questions HEEE that promotes memorization. In fact, the pre-servive teachers emphasized special schools that prepare them for national examinations for university entrance were not able to develop their critical thinking because of the use of multiple-choice questions in the HEEE. Because of much focus on preparing for the HEEE, pre-service teachers felt that their critical thinking skill development necessary for problem-solving was compromised. Pre-service teachers thought that they were good problem-solvers, until they did their undergraduate studies, only to realize that they had not attained proficiency in problem-solving because of learning physics through rote memory. Pre-service teachers indicated that insufficient laboratory tools lead to lack of translating theoretical information into practical physics in terms of the physics learning environment. Crowded class conditions provide insufficient space for physics problem-solving practical activities. They indicated that they gained knowledge at the comprehension level, but could not reach the analytical and synthetic levels. Conceptual learning gains in introductory physics courses and conceptual understanding in high school (Şahin, 2010; Zavala et al., 2007) and university learning (Şahin, 2009) have a direct impact on advanced learning.

Implications

Pre-service teachers' perceptions of factors influencing their performance in physics problem-solving are interpreted according to the research data. This study points to various issues the pre-service teachers encountered during their education in solving physics problems. To resolve the issues on developing pre-service teacher problem-solving abilities, this study implies the need for: (i) equal opportunities; (ii) knowledge integration; and (iii) learning affordances.

Equal Opportunities

According to data, students in majority of Turkish schools do not have equal opportunities for developing physics problem-solving abilities. For example, the problem-solving abilities of pre-service teachers who were graduates of Anatolian High School, Private High School, and Science High School were higher than those who graduated from Super High School and Anatolian Teacher Training High School because of the school status. The equality difference comes from the school's type. Because these schools include the type of Anatolian High School, Private High School, and Science High School. They have students over the standard level. Because students are selected to these schools according to the national exam scores, they usually have proficiency level physics teachers, or teachers could have the opportunity to teach physics in these schools according to the professional experience or examination scores of professional developments. However, especially private schools and science schools present much more weekly physics course hours than usual. This opportunity could provide students interaction with physics problem-solving processes and activities much more than usual. Other school types have standard level weekly physics course hours. Besides, they have almost the same student and teacher level. On the other hand, since pre-service teachers who participating physics courses are not paying serious attention to learn how to solve physics problems, there are not meaningful difference between undergraduate programs and gender of pre-service teachers such as physics teaching, science, physics, elementary and computer and instructional technology.

The gap in student knowledge and abilities is a world-wide educational phenomenon between the haves and have-nots. Turkey, according to accounts given in this study, seems to be perpetuating the problem of inequality. Such social justice issues should be addressed if we want all potential pre-service teachers in Turkey to have equal opportunities to learn physics problem-solving. Evidence in this study clearly implies that the goal of science education, regardless of schools, should be to provide students equal and more opportunities for problem-solving at all levels from early childhood to higher education. To achieve this goal, students also have an important role to play. They should also put forth conscious effort to learn physics and perceive learning physics as more than a subject to pass but a course that provides the development of a set of life-long abilities. At the same time, the teachers must be knowledgeable about teaching approaches that help students to learn problem-solving. TMNE ought to take steps in providing equal opportunities to build student self-efficacy in physics problem-solving. It requires the TMNE to make policy changes concerning the nature of government examination and the administration of large-scale evaluation. Equity issues raised in this Turkish study on pre-service teachers' perceptions about their physics problem-solving abilities have wider applications.

Knowledge Integration

Since the pre-service teachers' readiness level in fundamental physics concepts and the skills of mathematical operations are deficient, they have a lack of ability to integrate their knowledge in solving physics problems. Developing a deep understanding of physics concepts, principles, rules, and unit conversions are requiring necessary abilities at the K-12 level. This study also indicated that the pre-service teachers were confused in physics problem-solving because their early education adopted a random rather than a strategic approach. The study also suggests that the pre-service teachers did not realize the importance of developing problem-solving abilities in physics to the desired level. Thus, pre-service teacher knowledge integration involves both the "what" and "how" of physics learning, beginning from early childhood to tertiary science education. Teacher educators need to take into consideration this kind of knowledge that can be best developed to improve physics problem-solving abilities in the preparation of the pre-service teachers. Pre-service teachers can then be expected to integrate the same strategies systematically with their own students. This knowledge integration will have positive effects on school students' learning and achievement. On the contrary, if pre-service teachers have not developed sufficient physics problem-solving abilities, they will not be able to advance high school students' physics problem-solving abilities. Because pre-service teachers potentially have a huge impact on high school education, a strong knowledge baseline must be set from which to develop the physics problem-solving abilities of students at the university level.

The pre-service teachers indicated that the insufficient number of problems solved was one of the reasons why they did not develop the ability to solve physics problems. If traditional instruction can be decreased in the beginning stage and if the number of problems students should work is increased, problem-solving abilities can be developed (Moreno, 2006). An increasing number of studies emphasize that teacher specialization in problem-solving enables the organization and presentation of the knowledge in different ways (Sabella, & Redish, 2007). As a result, paying attention to developing complex processes and elaborating knowledge from different dimensions are necessary to improve pre-service teachers' abilities in physics problem-solving.

A series of efforts need to implement to eliminate difficulties encountered in the problem-solving process (Bingham, 2004). Thus, a specially designed course should be developed and implemented in physics education programs to improve physics problem-solving abilities of pre-service teachers. It could take place special courses with special context, activities, and following problem-solving strategies especially focussing to improve physics problem-solving abilities of pre-service teachers. This process needs to be implemented step by step according to the effective selected activities which contain detail descriptions and applications about the stages of the physics problem-solving. After pre-service teachers analyzed common mistakes of pre-service teachers' physics problem-solving process, they could be warned about defined inabilities for the physics problem-solving process. When they are informed about determined problem-solving strategies, they need to orientate for practicing problem-solving strategies to the different kinds of problems based on two indicating application stages. This process could ensure pre-service teachers to be ready same kind of perceptions to organize their solution strategies for the physics problem-solving process. Because it is emphasized that skilled problem solvers manage their solution strategies according to the main principles or concepts (Ince, 2018; Reddy & Panacharoensawad, 2017). This process ensures students integrate major ideas, context, and procedures as well-integrated knowledge base for guiding their problem-solving with a hierarchically structured form (Ince, 2018; Simamora et al., 2017). By this way, pre-service teachers could resolve physics problem-solving skills based on the deficiency points and have a habit and common approach about physics problem-solving strategies.

Learning Affordances

The pre-service teachers think that the secondary school's physics teachers and the university physics instructors have great impact on the development of their problem-solving abilities. They believe that teacher knowledge and instructional inadequacy in problem-solving develop negative attitudes and strongly affect students' physics problem-solving abilities. Thus, pre-service teachers need to be provided conceptual, physical, and care affordances.

Conceptual causes contain the poor understanding of the necessary physics concepts, principles, and rules that lead to difficulties in unit conversions; developing test techniques concentrating only on the results rather than the problem-solving stages; using the appropriate methods and techniques efficiently and having adequate in-class problem-solving practice. This reality necessitates the quality assurances of physics teachers and physics teaching and learning in secondary and higher education. Fact that most pre-service teacher perceptions toward physics are shaped early on in their education, there is a need for change in physics teaching at the high school and university levels to accommodate the learning needs of the pre-service teachers.

The instructional practice of lectures in Turkish physics classes at all levels should give way to defensible methods of teaching physics. Problem-solving abilities can be developed by decreasing traditional instruction and increasing strategies of teaching that promote physics pre-service teacher ownership of learning (Moreno, 2006).For students' responsibility to take root, physics teachers and university instructors need to make their lessons interesting by increasing the sense of wonder, resolving their prejudices toward physics, informing about what worked where, giving examples from daily life, and teaching them how to create the physics formula instead of merely having them memorize (Moelter & Jackson, 2012). Physics teachers need to teach clearly by bringing physics to the level of students, developing experiences that would create interest in physics classes. Some pedagogical practices are using technology, bringing visuals to the classroom, giving concrete examples, and engaging students in investigations. These experiences will promote interactive and interpretive discourse about the conceptual and practical as advocated by contemporary physics educators and teacher educators (Anderson et al., 2014; Mulhall, 2005). Those physics teachers and educators who advocate conceptual change inquiry have been suggesting the probing of learners' conceptions and using these as frameworks to learn scientific models and explanations through a variety of methods (Glynn et al., 1995; Treagust & Duit, 2015). Effect level of teaching methods of pre-service teachers during the practicing lesson contributes to the student understanding and the construction of fundamental physics knowledge of students (Saka & Saka, 2006). Such conceptual change inquiry teaching practices have greater likelihood to develop students' understanding of physics explanatory models and using these in manipulating physics problems. Making a conscious effort to improve mathematics knowledge and understanding as well as developing language literacy in physics class based on aims and objectives of the physics curriculum (Achieve, 2013) will likely improve student problem-solving abilities. Hence, to improve pre-service teachers' problem-solving abilities in physics, secondary and tertiary teachers need to have professional development in defensible methods of teaching physics and physic problem-solving. Studies must be conducted on the effect of professional learning of physics teachers on their classroom enactment and student development of physics problem-solving.

Physical affordance is concerned with the insufficiency of the necessary materials needed to teach physics. To accommodate the need for rich and relevant physics materials, new curriculum should be developed, and textbooks written using evidence-based problem-solving pedagogies. Curriculum developers and science educators need to collaborate in determining the physics core ideas and related mathematical concepts that are useful and necessary to the understanding of physics problem-solving. The pre-service teachers pointed out is the inability of teachers to make physics courses likable and enjoyable and providing orientations to focus on problem-solving stages and strategies of the problem-solving process. Therefore, pre-service teachers should see their education as an integral process of "growth" and gradual "development" based on their effective teaching through collaborative investigations into physics problems-solving that has personal meaning. Pre-service teachers must also be inquirers and strategic planners and be open to continual development in physics problem-solving. When such dispositions to physics learning are embraced, pre-service teachers will be able to foster, support, and motivate their students. Such dispositions should improve pre-service teachers' abilities to physics learning (Liu et al., 2017; Saad & BouJaoude, 2012) and this, in turn, will spill over into learning physics problem-solving strategies and stages. Pre-service teachers must have a commitment to their own professional development for the benefit of themselves and their students.

Care affordance is regarded as requiring taking into consideration problem-solving strategies and stages in the process of physics problem-solving. In this context, various researchers in different areas have stressed the positive contributions to teaching strategic problem-solving in physics education (Mualem & Eylon, 2010; Warren, 2010). One crucial result of strategic problem-solving in physics education is student academic achievement (Foster, 2000; Ghavami, 2003). On the other hand, according to Çalışkan et al. (2010), strategic methods of problem-solving promote the development of students' cognitive and meta-cognitive awareness. Simultaneously, problem-solving strategies provide an increase in the metacognitive awareness level of students and make it easier for them to transfer their knowledge to other fields (Metallidou, 2009).Therefore, physics education needs to support strategic problem-solving by providing enough opportunities in effective learning environments, including computer-assisted instruction (Uclo et al., 2005). A problem-solving strategy is defined as harmonizing the stages of a problem in various ways that lead to its solution. In this process, every stage taken into consideration constitutes a general problem-solving strategy (Schunn et al., 2005), while the sub-stages compose more specific behaviors (Çalışkan & Selçuk, 2010). Besides, it is stated that problem-solving stages can also change according to time, person, and situation (Bingham, 2004). Therefore, when students consider the stages of problem-solving, they may gain more strategic knowledge (Pol et al., 2008), which enables them to analyze the problem, apply relevant content knowledge, plan, and solve the problem (Gunawan et al., 2017). In line with this view, it is crucially important that teacher educators take an active role in encouraging pre-service teachers regardless of grade level to improve their strategic problem-solving abilities so that they can use it consciously and systematically in their classroom (Selçuk et al., 2007). It is revealed that pre-service teachers could reach this contribution regarding for the problem-solving skill development by the way caring problem-solving strategies and stages for the process of physics problem-solving.

In this study, we indicated a different aspect of the producing contribution to the physics problem-solving skills development of the pre-service teachers by identifying the factors influencing well-structured physics problem-solving abilities as perceived by pre-service teachers based on their own educational and learning experiences. According to pre-service teachers, the factors influencing their physics problem-solving abilities, ranking from most to least, are as follows: pre-service teachers' characteristics; quality of secondary or university physics teaching; secondary school physics education, and physics learning environment. In order to develop pre-service teacher problem-solving abilities, it is necessary to resolve the issues posed by the foregoing factors: (i) equal opportunities; (ii) knowledge integration; and (iii) learning affordances. These indications could regard as meaningful tools for stimulating and awarding pre-service teachers about sources of common errors and ensuring them to follow more strategic pathways to be an effective problem solver. At the end of this process, when pre-service teachers reflect their own problem-solving skills to their students more beyond the standard level, they could ensure direct contribution to their students' physics problem-solving skills and physics achievements. It is considered these implications for contextual challenges are relevant to world-wide physics education.

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Appendix. *The analysis results of mean and standard deviation of pre-service teachers' perceptions of the factors influencing their physics problem-solving (Never-1, Seldom-2, Sometimes-3, Often-4, Always-5).*

Pre-service teachers' perceptions of the factors influencing their physics problem-solving abilities (N=1185)	Mean	Standard Deviation
Difficulty you experienced in mathematical operations affects your ability to solve physics problems negatively?	2.44	1.10
Do your study habits affect your ability to solve physics problems negatively?	2.76	1.27
Do the weekly course hours being very limited during the pre-university education process affect your ability to solve physics problems negatively?	2.77	1.27
Do you believe that the place where you stay, not being conducive, to study effected your ability to solve physics problems negatively?	2.87	1.29
Do you think your lack of basic geometry knowledge essential for physics courses affected your ability to solve physics problems negatively?	2.91	1.30
Does your bias toward physics courses affect your ability to solve physics problems negatively?	3.05	1.31
Do you think you're having been conditioned only to obtain test results by the cram schools you attended affected your competency in solving physics problems negatively?	3.15	1.31
Do the crowded conditions of the classes affect your ability to solve physics problems negatively?	3.15	1.27
Do the physics courses containing a lot of formulas that require mathematical operations affect your ability to solve physics problems negatively?	3.23	1.25
Does your inability to put theoretic knowledge into practice effect your ability to solve physics problems negatively?	3.24	1.24
Does the absence of group works and the activities that provide the students with a sense of responsibility (project works) effect your ability to solve physics problems negatively?	3.25	1.23
Do you think the fact that there were no lessons or courses that were taught by the teachers of different disciplines during secondary education affected your ability to solve physics problems negatively?	3.21	1.34
Does lacking the knowledge of the physics-related concepts at a satisfactory level affect your ability to solve physics problems negatively?	3.30	1.21
Do you think lacking the knowledge of core concepts related to physics, and having difficulty relating one into another effect your ability to solve physics problems negatively?	3.33	1.03
Does the teachers' insufficient use of board exercises in physics education effect the development of problem-solving skills negatively?	3.35	1.22
Does the insufficiency of pre-university physics education affect your ability to solve physics problems negatively?	3.39	1.37
Does the insufficiency of the examples of problem covered during the course affect your ability to solve physics problems negatively?	3.42	1.14
Does the inadequacy of the materials necessary for physics courses affect your ability to solve physics problems negatively?	3.45	1.22
Does the physics teacher's inability to use the appropriate methods and techniques efficiently in physics education affect your ability to solve physics problems negatively?	3.61	1.14
Do you think that dependency of HEEE on test-solving techniques lead to the habit of focusing only on the result regardless of the problem-solving steps?	3.62	1.23
Does the teacher's inability to make the physics course likable and enjoyable effect your ability to solve physics problems negatively?	3.63	1.23