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Abstract

The purpose of the present study was to investigate pre-service science teachers' perceptions of science teaching. To this end the participants' perceptions of their pedagogical knowledge (PK) and pedagogical content knowledge (PCK) were examined. Furthermore, it was aimed to investigate how pre-service science teachers' perceptions were differed according to their level of achievement regarding PK and PCK. 176 fourth year pre-service science teachers participated in the study. The design of the study was planned as a survey and three scales were given to the participants to collect data. The data obtained from the scales were analyzed using both descriptive and inferential statistics. The results of the study revealed that pre-service science teachers perceived themselves as competent in terms of both PK and PCK. When components of PK were examined, participants' perceptions were high regarding classroom management, learners and learning, lesson planning and assessment. With respect to components of PCK, participants perceived that they had high level knowledge of science instructional strategies, knowledge of science learners, knowledge of science misconceptions, knowledge of science curriculum and knowledge of science assessment. Moreover, it was observed that level of achievement did not show any differences on pre-service science teachers' perceptions of PK and PCK.

Introduction

The role of teachers has a great influence on student learning (Darling-Hammond, 2000; McKenzie et al., 2005) and therefore studies researching teacher knowledge have great importance (Aydın, 2012). Science teacher knowledge has been the focus of research for more than 50 years now, and it has been studied in different ways by many researchers (Abell, 2007; Carlson & Daehler, 2019; Shulman, 1986). Shulman introduced a teacher knowledge model in 1986 comprising three domains: pedagogical content knowledge (PCK), curricular knowledge and content knowledge. One year later, he added general pedagogical knowledge (GPK), knowledge of educational context, knowledge of learners and their characteristics, knowledge of educational ends, purposes and values and their philosophical and historical grounds as other categories of teacher knowledge. Following Shulman's work, other researchers proposed different models of teacher knowledge (Abell, 2007; Chan & Hume, 2019; Gess-Newsome, 2015; Grossman, 1990; Magnusson et al., 1999; Park & Oliver, 2008). Moreover, based on Shulman's work, some researchers introduced some new components of PCK such as orientation to teaching science, knowledge of assessments etc. Abell's (2007) science teacher knowledge model, which was based on Grossman (1990) and Magnuson et al. (1999) models, was used as a framework in this study as shown in Figure 1. Teacher knowledge comprises four different domains according to this model: pedagogical content knowledge, pedagogical knowledge, subject matter knowledge (SMK) and knowledge of context. The study focused on two domains of teacher knowledge and aims to investigate pre-service science teachers' perceptions regarding their PK and PCK.

Pedagogical Knowledge

Shulman defined pedagogical knowledge (PK) as the "broad principles and strategies of classroom management and organization that appear to transcend subject matter" (1987, p. 8). Similarly, Lederman and Gess-Newsome defined pedagogical knowledge as a "teacher's knowledge of general pedagogy such as classroom management, questioning, planning, and so forth" (1992, p.16). Koehler et al. (2013) emphasized that PK is concerned with knowledge about teaching and learning process, and it involves lesson planning, classroom management, different instructional and assessment methods and the individual properties of learners. Since teaching content without having PK is not possible, teachers should understand PK and develop a deep understanding of it. Furthermore, since the ability to teach effectively depends upon teachers' perceptions of their PK (Choy et al., 2012), understanding pre-service teachers' perceptions of PK is crucial.

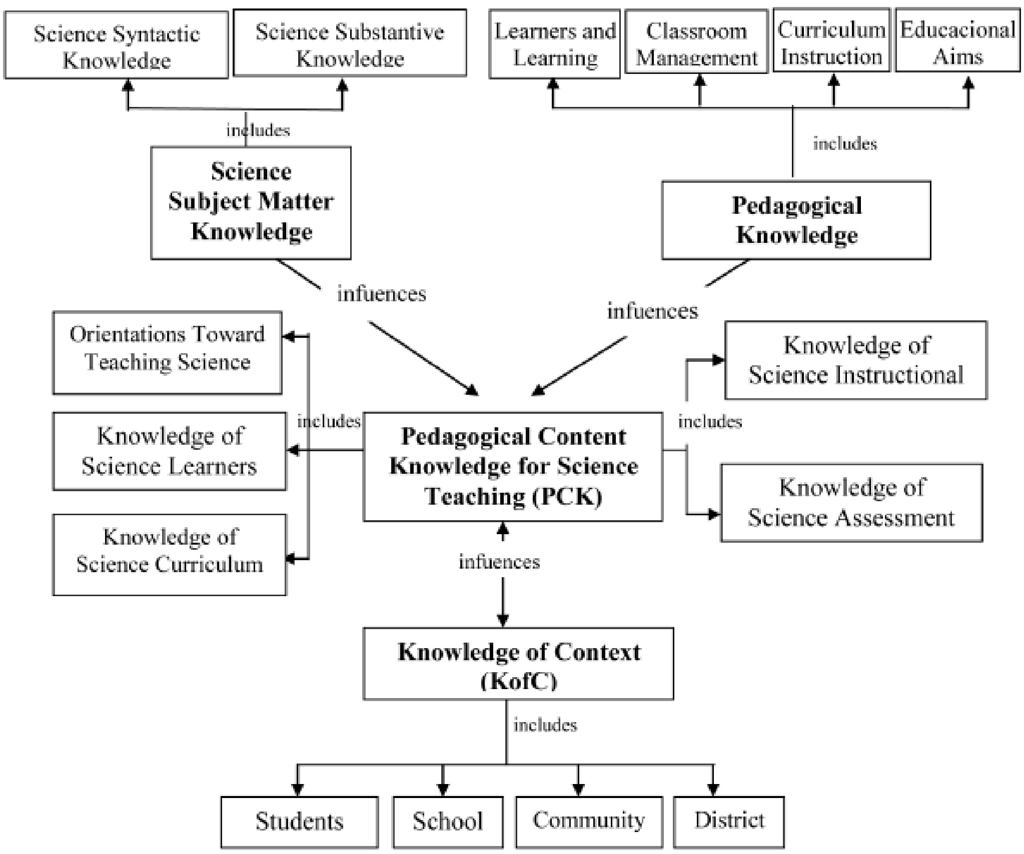

Figure 1. Abell's Model (2007) of Science Teacher Knowledge (p. 1107)

Based on the Shulman's definition of PK, Grossman (1990) differentiated between PK and PCK by stating that PK is separate from PCK in that it is not subject matter specific. For instance, PK is not specific to science, mathematics or literature teaching. Similarly, Demirdogen (2012) in her study pointed out that pedagogy consists of general teaching, assessment and reinforcement etc. stating that PK is not discipline-specific knowledge. It is important to make a clear distinction between PK and PCK since the present study focuses on both PK and PCK. PCK is concerned with how subject matter is made accessible for students rather than with the general principles of teaching and learning. Morine-Dershimer and Kent (1999) conceptualized three major areas that contribute to the development of PK as follows: classroom management and organization, instructional models and strategies and classroom communication and discourse. They explained classroom management as using time efficiently, applying instructional strategies and preventing problems in the classroom, and it also has influence on student learning. Instructional models and strategies are another element contributing to PK and involve knowledge about alternative ways of instruction and how to use these alternatives in an appropriate manner. Lastly, classroom discourse is a crucial component of PK because teachers need to improve communication in the classroom to meet the different needs of students.

In the present study four components are covered under the category of PK: learners and learning, classroom management, assessment and lesson planning. This categorization is in parallel with Abell's model (2007) and studies related to PK in the literature (König et al., 2011; Voss et al., 2011). The first component is classroom management, which König and Kramer (2015) defined as the teacher's specific knowledge and skills related to the challenge of managing a classroom. According to another study conducted by König and Blömeke (2012), classroom management also includes teacher knowledge related to motivating students both individually and in a group, preventing and eliminating problems and preventing conflicts in the classroom as well as using time in an effective way (Baumert et al, 2010). Classroom management is one of the fundamental factors in classrooms for learning to take place and it is linked to pedagogical knowledge (Garrahy et al., 2005). Secondly, planning is a crucial component of instruction since it is a way of achieving the objectives of a lesson and it can sometimes be challenging for teachers (Saad et al., 2014). Lesson planning includes writing lesson plans and providing resources for students. Teachers need to plan and form an environment in the classroom that resulted in learning (Choy et al., 2013). Moreover, lesson planning directs the teacher's actions in the classroom. Lesson planning provides beginning teachers with what is required for teaching and prepares them for problems that could potentially develop when delivering instruction (Hayes, 2003). The other component of PK is learning and learners. This component involves knowledge about using a diverse range of strategies in order to attract students' attention to the lesson and promote their thinking skills (Wong et al., 2012). Borko and Putnam (1996, as cited in Harr et al., 2014, p. 2) described it as "knowledge and beliefs about learners, how they learn and how that learning can be fostered by teaching" (p.676). Having this type of knowledge is necessary for teachers to understand students' learning processes. Similarly, Voss et al. (2012) advocated that knowledge about the learning process is a component of PK since every student has different characteristics, which have the potential to influence their learning. Lastly, assessment is regarded as a component of PK (Tatto et al., 2008) and further stated that knowledge of classroom assessment is crucial in enabling teachers to observe students' progress toward their goals and in helping them to adapt their instruction to the individual needs of their students.

Pedagogical Content Knowledge

The notion of pedagogical content knowledge (PCK) was firstly put forward by Shulman (1986) and he defined it as "special amalgam of content and pedagogy that is uniquely the province of teachers, their own special form of professional understanding" (1987, p. 8) and as "the ways of representing and formulating a subject that make it comprehensible to others" (p. 9). Shulman (1987) noted that PCK is the combination of content and pedagogy in order to make the topic accessible to the different interests and abilities of learners. He believed that teacher education programs should combine these two kinds of knowledge. It is the knowledge specific to teachers and that distinguishes teachers from biologists, chemists etc. To illustrate, a scientist does not have to deal with how to teach the subject whereas teachers need to use their PCK in order make the subject accessible to learners with the help of analogies, illustrations. PCK helps teachers to make use of their content knowledge for the purpose of instruction. As Friedrichsen (2008) pointed out, instead of introducing new concepts for investigating science teachers' knowledge, PCK and its components should be used in practice and in studies. There are many studies in the literature examining pre-service teachers' PCK from different point of views. Some of them concentrated on the development of PCK (Adadan & Oner, 2014; Brown et al., 2013; Ekiz-Kıran et al., 2021; Friedrichsen & Abell, 2013; Hume & Berry, 2011; Lancaster & Bain, 2019; Nilsson & Loughran, 2012) while others focused on the nature of the components of PCK and relationship between components (Aydin et al., 2015; Kaya, 2009) and the relationship between SMK and PCK (Canbazoğlu et al., 2010; Ding & Leung, 2014) and developing rubrics for portraying both PCK and content knowledge (CK) (Kind, 2019).

There are five components of PCK based on Abell's Model (2007) which is based on mostly Magnusson et al. (1999) PCK model. Magnusson and colleagues approached to PCK model in a different way and adapted it for science discipline. In the current study four of these components were covered. The first component is knowledge of strategies for teaching science including subject specific strategies, which are related to teaching science, and topic specific strategies, which are related to teaching one topic in science. Therefore, subject specific strategies are more general (Magnusson et al, 1999). Knowledge of subject specific strategies includes knowledge about the general approaches for teaching science such as the learning cycle, guided inquiry, conceptual changes, using the laboratory etc. Teachers should be able to use different instructional strategies properly while teaching science. The second component, which is the knowledge of the science curriculum, enables teachers to develop an understanding about the connection between topics and curriculum in a holistic fashion and to make judgments about what should be included in the lesson in order to achieve the goals, and also how to arrange activities (Park & Oliver, 2008). This component also deals with how to implement the curriculum in the classroom and how to use materials while teaching science. The third component is knowledge of science assessment, which consists of two categories: Knowledge of the aspects of science learning, which includes what to assess in student learning while teaching science. The second one concerns the teachers' knowledge about assessment and includes instruments, procedures, approaches and activities (Magnusson et al, 1999). The fourth component of PCK is knowledge of science learners. There are two categories that make up this component: Knowledge of the requirements for learning and knowledge of the areas where students have difficulty. The former one includes teachers' knowledge and beliefs related to what students already know about specific science topics and the different approaches towards learning held by students. The latter one includes teachers' knowledge about students' difficulties and misconceptions regarding specific science topics. The last component of PCK is orientation towards science teaching, which is defined as "teachers' knowledge and beliefs about the purposes and goals for teaching a subject at a particular grade level" (Magnusson et al., 1999, p. 97) which is not in the scope of the present study. Orientations to teaching science component were removed since the definition and how to measure orientations has ill-structured (Friedrichsen et al., 2011) and Henze and Barendsen (2019) specified that "we consider orientations to be less content-specific than the other components and Magnusson et al. themselves present orientations as an underlying influence on the components knowledge of curriculum and knowledge of assessment" (p. 205). Therefore, orientation component was excluded in the present study.

Studies related to teacher knowledge mostly focused on PCK and SMK in the literature, where PK is given less importance (König, 2013; König et al., 2011; OECD, 2014; Voss et al., 2011). Moreover, PK studies were mostly carried out with pre-service mathematics teachers (Blömeke et al., 2008; Voss et al., 2011). The literature calls for more research examining the PK of pre-service teachers in different subject areas (Choy, et al., 2012; Malva et al., 2020; Voss, Kunter & Anders, 2010). Additionally, PCK has been studied for more than twenty years and the majority of the studies are qualitative in nature but Abell (2008) and Jüttner et al.,(2013) suggested the use of quantitative and mixed method studies. As Borowski et al. (2012) pointed out, quantitative PCK studies were mostly carried out in mathematics education while science education lacks large scale studies (Martin & Jamieson-Proctor, 2020; Schmelzing et al., 2013). Perceptions show differences from person to person, and it could be useful to elicit pre-service teachers' perceptions regarding their knowledge to support their learning (Bukova-Guzel et al., 2013). The purpose of the present study is to present pre-service science teachers' perceptions pertinent to science teaching. To this end, their perceptions of their PK and PCK are investigated together. The following research questions and sub-research questions guide the current study: "What are pre-service science teachers' perceptions of their pedagogical knowledge? and What are pre-service science teachers' perceptions of their pedagogical content knowledge? Moreover, whether their perceptions of their pedagogical knowledge and its components (learners and learning, lesson planning, classroom management and assessment) and pedagogical content knowledge and its components (knowledge of instructional strategies, knowledge of learners, knowledge of assessment, knowledge of curriculum) differ according to level of achievement was investigated.

Method

Research Design

Survey design was used in the current study. A questionnaire that included three scales was used for collecting data to describe pre-service science teachers' perceptions of their PK and PCK in teaching science. Accessible population was identified and all the 4th year students attending three state universities having elementary science education departments in the capital city of Turkey were participated in the study. The reason for choosing fourth year students was that they were about to complete methodology and pedagogy courses and they have been in the program for a long time. As there are three state universities having elementary science education departments in Ankara, data were collected from all three universities. 176 participants were involved in the present study (*N*=176) spread as follows: 15% (*n*=28) of the participants were from Middle East Technical University, 36.4% (*n*=64) from Gazi University and 47.7% (*n*=84) from Hacettepe University. Most of the participants were female (77.3 %) and almost all of them wanted to become a teacher after graduation (96.6 %).

Data Collection Instrument

Three scales were utilized in the current study. Pre-service science teachers' background knowledge was obtained through the demographic characteristics part of the instrument, which asked for the pre-service science teachers' gender, type of high school, their GPA in the 7^{th} semester, and their desire for teaching after graduation. The second scale used in the study was "Perceptions of Knowledge and Skills in Teaching" (PKST), which was developed by Choy et al. (2012). It aimed to present pre-service and beginning teachers' perceptions of their PK. The participants were asked to rate their perceptions of PK on a 5-point Likert scale with the following points: "no knowledge at all", "a little knowledge", "some knowledge", "knowledgeable" and "highly knowledgeable". The reliability of the original instrument was found as .95. The adaptation of the instrument into Turkish was carried out by the researchers. The content validity evidence for the instrument was obtained through three expert opinions.

Later, it was piloted with 193 pre-service teachers at a state university located in the western part of Turkey and Exploratory factor analysis (EFA) was conducted in order to specify how many factors were present in the scale (Tabachnick & Fidell, 2007). Based on the results, it was decided to include four components and these four components explained 58.02 % of the total variance. The components were named as follows: classroom management, learners and learning, lesson planning and assessment. There were 27 items in the final Turkish form. The Cronbach Alpha values for the four components were .86, .87, .85, and .84 respectively and the overall value was found as .94, which was high (Pallant, 2010).

The third scale, which was originally developed by Bukova-Guzel et al. (2013), aimed to identify the perceptions of pre-service mathematics teachers regarding their PCK. There were 17 items and five components in the original instrument: knowledge of teaching strategies, knowledge of mathematical language and symbols, knowledge of misconceptions, knowledge of learners and knowledge of curriculum. The reliability for the overall instrument was calculated as .87 and for the factors it was found as .78, .60, .73, .64 and .83, respectively. For the validity, confirmatory factor analysis results yielded acceptable fit indices ($\chi 2$/df =1.40, CFI = 0.90, GFI = 0.86, RMSEA = 0.060, RMR = 0.040) in the original study. The instrument was adapted to science teaching by the researchers. Two main changes were made while adapting the instrument: the first one was replacing the word "mathematics" by "science" in each item.

Also, items in one of the components, the one related to knowledge of mathematical language and symbols, were removed and replaced by a component called "knowledge of assessment." The reason for removing the component related to mathematical language and symbols was that symbols are not used in the present science curriculum. Knowledge of assessment, which is a component of PCK according to Abell's model of teacher knowledge (2007), was missing in the original instrument and was added as a component. The last version of the instrument was presented to three experts to take their opinions. Later, the pilot study was conducted with 104 pre-service teachers at a state university. Since the researchers already had a model related to the instrument, confirmatory factor analysis (CFA) was conducted using LISREL 9.2 program. The results of the analysis indicated that the RMSEA value was .078, which is considered an acceptable fit (Tabachnick & Fidell, 2007). Moreover, the goodness of fit indices were found to be at acceptable levels ($\chi 2$=200.14, *df*= 122 χ2/df =1.64, CFI=.91, IFI= .91, RMR= .34). The Cronbach alpha reliability for the whole instrument was found as .88 and the components were calculated as: knowledge of instructional strategies .77; knowledge of science learners .63; knowledge of science misconceptions .64; knowledge of science curriculum .75; knowledge of science assessment .72. Final version of the scale included five components and 17 items. The time for completing the scales was approximately 25-30 minutes. Confidentiality was ensured by not including the names of the participants. Participants who read and signed the informed consent form were given the instruments.

Data Analysis Procedure

Descriptive statistics were used and mean and standard deviations were calculated in order to present pre-service teachers' perceptions related to their PK and PCK, Moreover, in order to examine whether pre-service science teachers' perceptions of their PK and PCK differed in terms level of achievement, a one-way ANOVA was used. Level of achievement had three levels: satisfactory (ranged between 2.02 and 2.89), honor (ranged between 3.06 and 3.44) and high honor (ranged between 3.51 and 3.72).

Results

Pre-service Science Teachers' Perceptions Related to Their Pedagogical Knowledge

The overall mean value for the pre-service science teachers' perceptions related to PK was 4.14 (*SD*=.84) and mean scores ranged between 3.86 and 4.40. In the study a higher mean value indicated that participants perceived themselves as having higher perceptions of their PK. Mean, and standard deviation were calculated for each dimension and are provided in Table 1.

Table 1. Descriptive Statistics for Dimensions of Perceptions of PK (N=176)

	M	*SD*
Learners and Learning	4.16	.86
Lesson Planning	4.20	.83
Assessment	4.24	.80
Classroom Management	4.03	.88

According to the results, the mean scores of learners and learning (*M*=4.16, *SD*=.86), lesson planning (*M*=4.20, *SD*=.83) and assessment (*M*=4.24, *SD*= .80) were close to each other and considered as being close to complete knowledge. On the other hand, the mean scores of classroom management (*M*=4.03, *SD*=. 88) were lower than the other three aspects. Descriptive statistics for each item are given in Table 2.

Table 2. Descriptive Statistics for PKST

Items	*M*	*SD*	1-2*	3**	4-5***
Learners and Learning					
1. Developing students' interest in learning	4.10	.78	5.7	6.8	87.5
2. Arousing students' interest towards subject	4.26	.76	5.7	2.3	92.1
3. Including critical thinking appropriately in the lessons	4.00	.94	9.7	9.7	80.7
4. Including creative thinking appropriately in the lessons	4.06	.91	10.8	2.3	87.0
5. Facilitating and stimulating thinking among students	4.20	.88	8.6	3.4	88.1
6. Using student-centered teaching and learning activities	4.37	.86	7.4	1.1	91.5
7. Asking students the right questions to facilitate their learning	4.19	.82	6.9	3.4	89.8
Lesson Planning					
8. Choosing appropriate teaching strategies for teaching particular topics	4.23	.81	5.7	4.5	89.8
9. Planning lessons that take into consideration the different abilities of students	4.13	.87	8.0	8.5	83.5
10. Determining appropriate teaching methods	4.22	.82	5.7	7.4	86.9
11. Planning student centered lessons	4.40	.77	4.5	4.0	91.4
12. Producing teaching materials	4.19	.83	6.9	4.0	89.2
13. Acquiring appropriate teaching materials	4.04	.87	6.9	13.6	79.5
Assessment					
14. Designing assessment tools (e.g., written tests, oral tests, science practical, etc.)	4.33	.78	4.5	5.7	89.7
15. Interpreting student' performance from test scores	4.24	.77	5.1	5.1	89.8
16. Using appropriate forms of assessment	4.18	.83	6.9	4.5	88.6
17. Using evaluative feedback to assist students in their progress	4.23	.83	6.3.	5.1	88.6
Classroom Management					
18. Teaching according to students' pace	4.3	.82	6.3	2.8	90.9
19. Diagnosing students' learning difficulties	4.2	.87	6.9	6.8	86.4
20. Managing individual students' learning effectively	4.0	.80	7.4	8.0	84.6
21. Applying appropriate classroom management techniques	4.0	.87	8.0	12.5	79.5
22. Managing students with behavioral and learning problems	3.8	.98	10.8	19.9	69.3
23. Using appropriate strategies to monitor student behavior	4.1	.90	9.1	5.7	85.2
24. Managing student discipline	3.9	.90	9.1	13.6	77.2
25. Managing time effectively	3.9	.93	8.6	18.8	72.8
26. Having coping skills	3.9	.90	9.1	15.3	75.5
27. Managing stress	3.8	.91	9.6	17.0	73.3

*percentage of no knowledge and a little knowledge ** percentage of moderate knowledge

***percentage of knowledgeable and highly knowledgeable

Pre-service Science Teachers' Perceptions Related to Their Pedagogical Content Knowledge (PCK)

Items with higher mean values revealed that the participants perceived themselves as having higher perceptions of their PCK. The overall mean value for the pre-service science teachers' perceptions of PCK was 4.07 (*SD*=.90) and mean scores ranged between 3.86 and 4.40. To identify participants' perceptions, mean and standard deviation were calculated for each dimension and are presented in Table 3.

Table 3. Descriptive Statistics for Dimensions of Perceptions Related to PCK

	M	*SD*
Knowledge of Science Inst. Strategies	4.15	.95
Knowledge of Science Learners	3.98	.96
Knowledge of Science Misconceptions	3.77	.97
Knowledge of Science Curriculum	4.17	.89
Knowledge of Science Assessment	4.08	.92

According to Table 4, the descriptive results indicated that the mean scores of knowledges of instructional strategies (*M*=4.15, *SD*=.95), knowledge of curriculum (*M*=4.17, *SD*=.89) and knowledge of assessment (*M*=4.08, *SD*=.92) were regarded as close to being "quite knowledgeable". On the other hand, knowledge of misconceptions (*M*=3.77, *SD*=.97) and knowledge of learners (*M*=3.98, *SD*=.96) aspects had lower mean values compared to the other three aspects. The descriptive results for each item are given in Table 4.

Table 4. Descriptive Statistics for Perceptions Related to PCK

Items	*M*	*SD*	1-2*	3**	4-5***
Knowledge of Science Inst. Strategies					
1. I can prepare activities while teaching science concepts	3.88	1.10	16.5	8.0	75.6
2. I can link science concepts to daily life	4.32	.90	9.1	2.3	88.7
3. I can use analogies while teaching science concepts	4.25	.85	7.4	4.0	88.7
Knowledge of Science Learners					
4. I know students' prior knowledge in a given science topic	3.93	.95	12.5	9.1	78.4
5. I can select science activities that are appropriate students' developmental level.	4.03	.95	13.1	5.1	81.8
Knowledge of Science Misconceptions.					
6. I can anticipate students' difficulty areas in a given science topic	3.77	.97	14.8	14.2	71.0
7. I know the students' possible misconceptions in a given science topic	3.73	.94	12.5	18.2	69.3
8. I can prepare activities that do not cause misconceptions	3.81	1.00	12.5	18.8	68.7

Items	*M*	*SD*	1-2*	3**	4-5***
Knowledge of Science Curriculum					
9. I have knowledge about the purposes of the elementary science curriculum	4.24	.85	5.1	9.7	85.2
10. I can prepare a lesson plan in a given science topic	4.23	.92	6.3	13.1	80.7
11. I prepare lesson plans that relate purposes of elementary science curriculum and needs of students	4.21	.91	9.1	4.0	87.0
12. I consider the objectives of the lesson while preparing lesson plan	4.53	.73	4.0	2.3	93.8
13. I can use assessment tools in elementary science curriculum	4.12	.92	9.7	7.4	82.9
14. I can assess the effectiveness of the science activities in curriculum	3.97	.92	10.8	10.8	78.4
Knowledge of Science Assessment					
15. I can evaluate students' science knowledge by using a variety of assessment tools (written / oral exams, portfolios, posters, self-evaluation and so on)	4.22	.91	9.1	5.7	85.3
16. I can develop various assessment tools appropriate for the elementary science curriculum	3.98	.93	10.2	13.6	76.1
17. I have the knowledge of different assessment methods in science teaching	4.05	.93	10.2	9.7	80.2

*percentage of never and rarely ** percentage of undecided

***percentage of usually and always

Pre-Service Science Teachers' Perceptions Related to Their PK and PCK According to Level of Achievement

The assumptions of the one-way ANOVA were independent observation, normality and homogeneity of variance (Green & Salkind, 2011), and these were also checked for both scales. The result of analysis showed that level of achievement did not have any significant difference on participants' perceptions of their PK, F (2, 173) = 1.55, p=.22 and their perceptions of their PCK, F (2, 173) = .89, p=.41. To conclude, when the differences in background variables were examined, the participants' perceptions of overall PK and PCK and their components did not differ according to level of achievement.

Discussion and Recommendations

The first research question aimed to investigate the pre-service science teachers' perceptions of their PCK. The findings revealed that pre-service science teachers perceived themselves as being close to "quite knowledgeable" in terms of PK. In other words, the participants generally had positive perceptions of their PK. The highest mean value was observed for "knowledge of assessment" whereas the lowest mean value was observed in “classroom management”. It could be concluded that the participants felt themselves more competent in assessment than classroom management. When the related studies conducted in a Turkish context were examined at first, it was seen that there were few studies directly focusing on pre-service teachers’ perceptions of PK. However, there were studies that examined the PK of pre-service teachers under the title Technological Pedagogical Content Knowledge (TPACK) framework. The TPACK framework stemmed from PCK and one of the components was PK. The findings of the present study were quite consistent with the results of Savas (2011) and Meric’s (2014) studies indicating that pre-service science teachers felt competent with respect to PK. The reason for the high perceptions of PK might be because the pre-service science teachers were in the last semester in their undergraduate education, and they had almost completed all the content area, methods and educational sciences courses as stated before.

Furthermore, since PK is not specific to science education, studies conducted with pre-service teachers from different departments regarding PK and its components were also considered. Oskay et al. (2009) studied pre-service chemistry teachers and found that they were be able to use different assessment strategies, which shows parallelism with the findings of the present study. Additionally, as studies have displayed, practicum courses have positive effects on students’ perceptions regarding classroom management and lesson planning, which are components of PK (Derri et al., 2014; Voss et al., 2011) and higher level of perceptions of PK in this study might be explained by the participants were about to complete their practicum courses at time data of data collection. However, results of the current study were conflicted with Okanlawon (2014) study which was carried out with pre-service science teachers in Nigeria context and aimed to examine their competencies in PK. Results indicated that participants did not feel themselves competent in terms of lesson planning, implementing and evaluating the instruction.

However, in the present study, most of the participants reported themselves as quite knowledgeable in planning student centered lessons, planning lessons considering different needs of students, choosing suitable teaching methods, using different forms of assessment and designing assessment tools. Therefore, the results of these studies were quite different. This might be due to cultural sensitivity of PK (OECD, 2014) and courses taken at science education departments might have different contents in Nigeria and in Turkey. Apart from this, perceived PK of participants in terms of lesson planning was high in this study. Participants felt that they have quite knowledge in planning lessons according to different needs of students, planning student centered lessons, and developing materials.

In line with the present study, Derri et al. (2014) suggested that practicum course that pre-service teachers took during two semesters had positive effects on preservice physical education teachers’ lesson planning skills in Greece. Their findings showed that after taking practicum courses, participants increased their skills in lesson planning and student evaluation. Similar to the findings of present study, since all participants almost completed their teaching practice courses, it could be the reason why their perceptions related to lesson planning wash high. The present study contributes to the literature by investigating pre-service science teachers’ perceptions regarding PK which is one of the neglected areas in research related to teacher knowledge domain.

The other research question focused on the participants' perceptions of their PCK. The findings indicated that majority of pre-service science teachers usually perceived their level of PCK as high. Consistent with these results, Koh et al. (2010) indicated that most of the pre-service teachers in their study reported that they perceived their PCK as high. When the components of the PCK were examined in detail, the pre-service science teachers reported that they felt the most competent in "knowledge of instructional strategies", "curriculum" and "assessment". The lowest scores corresponded to knowledge of students learning and students' misconceptions. It was concluded that majority of the pre-service science teachers' perceptions with respect to using analogies while teaching science and making connections to daily life were quite high in the current study. Along the same lines, Zembal- Saul et al. (2002) suggested that pre-service teachers were able to use multiple representations of the science concepts by using demonstrations and analogies in teaching practice, which they had developed with time and experience by the end of their programs.

Regarding the knowledge of science learners, the findings of the present study revealed that most of the pre-service teachers' perceptions were below the average of the overall PCK. The majority of the participants' perceptions were lower in items asking for knowing students' prior knowledge, anticipating their difficulty areas and noticing the misconceptions of students in a given topic, all of which is consistent with the relevant literature (Donnely & Hume; 2015; Kaya, 2009). With regard to knowledge of science assessment, the results of the present study indicated that the majority of the pre-service science teachers perceived themselves competent in evaluating students' knowledge using a variety of assessment methods, developing assessment tools and having enough knowledge about the methods of assessment used in science education as justified in the related literature (Donnely & Hume, 2015; Sasmaz Oren et al., 2011). It could be also concluded that pre-service science teachers perceived their knowledge of curriculum as high particularly when considering the objectives of the lesson while planning the lesson, preparing a lesson plan in a given science topic, and knowledge about the purposes of elementary science curriculum.

In addition, the findings of the current study showed that level of achievement did not make any difference in pre-service science teachers' perceptions with respect to both PK and PCK. The non-significant difference might be attributed to using the overall GPA of the participants, which includes grades of content area courses, general culture courses and teaching profession courses. Instead of using their GPA scores, participants could be asked to write their specific course grades like classroom management, educational psychology etc. in order to investigate the differences in level of achievement on perceptions of their PK. Similarly, their grades for teaching science methods, nature of science courses, assessment in science courses could be asked to examine the how their course grades differ in terms of their perceptions of PCK.

As implications for science education research, PK and PCK are crucial components of teachers' knowledge and it is important to elicit pre-service teachers' perceptions related to these knowledge domains. Based on their perceptions, it is possible to determine the areas in which they need to enhance their knowledge and skills. The current study pointed out that pre-service science teachers need to develop their knowledge of classroom management especially in terms of managing students with behavioral and learning problems, using time effectively, having coping skills and managing discipline and stress in the classroom. Classroom management courses in Turkey may be reviewed and course requirements could be refined to provide opportunities for practice in real classroom environments.

Furthermore, training programs could be designed for mentor teachers in practice courses since they are the role models for pre-service science teachers. In addition, although the participants reported that their perceptions of PK are high, there are some points that need to be given special attention. Based on the findings of the present study, pre-service science teachers' knowledge of learners and knowledge of misconceptions need to be improved. Pre-service science teachers had some problems particularly with anticipating students' difficulty areas and misconceptions. Therefore, courses in the science teacher education program like methods of science teaching could be revised in a way that increases pre-service science teachers' awareness in terms of elementary students' misconceptions in science.

This study has significant implications in terms of research. Perceptions of Knowledge and Skills instrument was translated into Turkish and administered to a large sample for validation in the pilot study. Exploratory factor analysis was applied, and the final version of the translated instrument included four factors. Moreover, as a second instrument, Perceptions of Pre-Service Mathematics Teachers Pedagogical Content Knowledge Scale, which was originally developed to be used in mathematics field, was adapted to science education. Confirmatory factor analysis was conducted in order to be sure whether its five-factor structure was suitable or not for pre-service science teachers. Finally, these two instruments were accepted as valid and reliable and could be used in future studies regarding PK and PCK.

As implications for further research, in order to get deeper information about participants' perceptions regarding PK and PCK, a variety of additional methods can be used to support the data collected from the scales like observation, lesson planning, interviews, card-sorting activities etc. Moreover, quantitative studies concentrating on specific science topics also need to be increased in the PCK field. By adapting instruments for particular science topics in order to investigate pre-service science teachers' perceptions, comparisons on PCK for different science topics could be done. Furthermore, results of the scales could be used to refine science teaching courses. Similarly, studies regarding PK also need further investigation. The sample of studies that include pre-service teachers from different subject areas and in-service teachers might be beneficial for making comparisons regarding their perceptions of PK. Lastly, longitudinal designs can be employed in further studies to monitor the progress of the participants and provide more detailed results regarding their PK and PCK.

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