Pre-service Science Teachers' Pedagogical Content Knowledge in the Physics, Chemistry, and Biology Topics

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Abstract
This study investigated pre-service science teachers' pedagogical content knowledge in the physics, chemistry, and biology topics. These topics were the light and sound, the physical and chemical changes, and reproduction, growth, and evolution. Qualitative research design was utilized. Data were collected from 33 pre-service science teachers (PSTs) by using open-ended questions. Data analysis was performed using descriptive analysis. The results indicated that some PCTs have sufficient information in terms of knowledge of learners in the above-mentioned topics. Ten PSTs mentioned that students have some misconceptions (e.g. light is a matter) in the light and sound. In the same way 17 PSTs stated that secondary school students have misconceptions (e.g. melting of was is a chemical change) in the chemistry topic. Also, seven participant wrote that students have misconceptions regarding biology topic (e.g. growth and evolution is the same). Moreover, some PSTs did not have sufficient information regarding instructional strategies and knowledge of assessment in these topics. Many of them stated that they use traditional instruction to overcome misconceptions on these topics. Likewise, many of them mentioned that they use open ended questions to determine these misconceptions. Implications for science teacher education are also presented.
Keywords: Science education, pedagogical content knowledge, pre-service science teacher.

Introduction

Although, pedagogical content knowledge (PCK) has been defined in various ways in the literature (Hashweh, 2005; Magnusson, Krajcik, & Borko, 1999; Park, Jang, Chen, & Jung, 2010; Shulman, 1987), Shulman's (1987) definition of PCK has been basic definition which ''. . .goes beyond knowledge of subject matter per se to the dimension of subject matter knowledge for teaching'' (p. 9). PCK is explained that teachers have to acquire content knowledge, curriculum knowledge, knowledge about learners and their characteristics, knowledge about educational contexts, and knowledge about educational purposes. Teachers have sufficient PCK can give content to their students in a reasonable way. Hence, teachers' PCK is a necessary for teaching (Shuman, 1987).

Magnusson, Krajcik, and Borko (1999) claimed that PCK possess five components. These are orientation toward science teaching, knowledge of students' understanding of science, knowledge of science curriculum, knowledge of instructional strategies, and knowledge of science assessment. In this study, dimensions of "knowledge of students' understanding of science", "knowledge of instructional strategies" and "knowledge of science assessment" have been discussed.

In the dimension of "knowledge of students' understanding of science" or "knowledge of learner", teachers must learn science concepts which students find difficult to learn. In other words, if teachers know misconceptions which students have in a specific topic, they should plan effective instruction by interpreting students' ideas (Halim, & Meerah, 2002; Magnusson, et al., 1999). Therefore, when teachers have insufficient content knowledge, they are not aware of students' misconceptions.

In the dimension of knowledge of instructional strategies, teachers must have the knowledge about subject-specific and topic-specific strategies. In other words, teachers should use pictures, drawings, examples, models, videos and analogies which are called teaching strategies to help students to understand specific science concepts (Halim, & Meerah, 2002). For instance, teachers have to know about the positive and negative sides of a biology model or practice about different possible experiments that could be used for a particular topic (Jüttner, Boone, Park, & Neuhaus, 2013). As Clermont, Borko, and Krajcik (1994) stated, if teachers do not know the positive and negative sides of demonstrations they cannot use the demonstrations in their courses and their students can have misconceptions in these courses. Likewise, Berg and Brouwer (1991) mentioned that physics teachers should use teaching strategies in order to remove misconceptions from their students in the physics topics.

Finally, in the dimension of "knowledge of the science assessment", teachers have to possess both knowledge of dimensions of science learning and knowledge of methods to assess students' learning within a specific topic (Magnusson, et al., 1999).

PCK is accepted as a domain specific by some researchers (Bektas, Ekiz, Tuysuz, Kutucu, Tarkin, & Uzuntiryaki-Kondakci, 2013; Halim, & Meerah, 2002; Jüttner et al. 2013; Van Driel, De Jong, & Verloop, 2002). For instance, teaching the light and sound for physics, cells for biology, and solutions for chemistry concepts need the different use of teachers' knowledge for the instructional strategies. In the same way, teachers use their knowledge in a different way while teaching the mole concept and teaching acid and bases in the chemistry courses (Bektas, et al., 2013).

In the literature, some research on PCK has been conducted separately in the field of physics (e.g. Halim, & Meerah, 2002), chemistry (e.g. Boz & Boz, 2008), and biology (e.g. Jüttner, et al., 2013). However, it is important to examine pre-service science teachers' pedagogical content knowledge in the physics, chemistry, and biology topics since they must have sufficient pedagogical knowledge in these science subjects to make effective instruction their classes in the future. Therefore, in this study, it was aimed to explore pre-service science teachers' pedagogical content knowledge in the physics, chemistry, and biology topics. Research questions of the study were presented below:

1. What is the knowledge of pre-service science teachers (PSTs) in terms of students' difficulties in understanding light and sound?
2. What is the knowledge of PSTs in terms of students' difficulties in understanding physical and chemical changes?
3. What is the knowledge of PSTs in terms of students' difficulties in understanding reproduction, growth, and evolution?
4. How do PSTs teach light and sound considering the knowledge of learners, instructional methods/strategies, and assessment of this topic?
5. How do PSTs teach physical and chemical changes considering the knowledge of learners, instructional methods/strategies, and assessment of this topic?
6. How do PSTs teach reproduction, growth, and evolution considering the knowledge of learners, instructional methods/strategies, and assessment of this topic?

Method

Research Design

In the present study, qualitative research method was utilized in order to explore the research questions. In other words, phenomenology which is the one of patterns of the qualitative research method was employed to deeply examine and describe in detail the opinions of the pre-service science teachers on the topics of light and sound, physical and chemical changes, and reproduction, growth, and evolution. (Patton, 2002; Yıldırım & Şimşek, 2011).

Sample

Criterion sampling, which is one of the purposeful sampling in the qualitative studies, was used to select suitable participants and investigate the opinions of PSTs in a comprehensive manner in qualitative research (Creswell, 2009). By using the criterion sampling, it was included the participants who meet a set of criteria that are previously determined (Yıldırım & Şimşek, 2011). Therefore, in this study, third grade 33 PSTs at the department of elementary science teacher education in a university in Turkey were selected as a participants of the study since they took both pedagogic formation lessons which are “teaching principles and methods”, “measurement and evaluation”, “instructional technology and material development”, and “special teaching methods for science” and content specific courses which are “general physics”, “general chemistry”, and “general biology”. Transferability of the study (external validity) was ensured by using criterion sampling and describing in detail research process and pattern.

This study was conducted during the course of special teaching methods for science. In this lesson, PSTs executed micro teaching and instructed many physics, chemistry, and biology topics (e.g. light and sound, physical and chemical changes, and reproduction, growth, and evolution). Each PCT is supposed to teach two assigned topics to the class. Each instruction lasts for approximately 20 minutes. The physics, chemistry, and biology topics are chosen from the national secondary school science curriculum of Turkey.

33 PSTs were participated in this study. Their age interval was 20-22. There were 28 female and 5 male PSTs as a participant. Due to research ethics considerations, names of the participants were not used and PSTs who participated in the research were classified with the codes of F1, F2 …F28, M1, M2 …M5. While F1 was the female who had the highest score in the exam, F28 was the female who had the lowest score in the exam. Same coding style was performed for the M1 and M5.

Data collection instruments

Open-ended questions as a document in qualitative studies were used to collect data in the study. Hence, other qualitative instruments such as interview and observation were not used and only document based on open-ended questions did not allow for triangulation to ensure the interval validity of the data (Marshall & Rossman, 2006; Bogdan & Biklen, 2007).

Open ended questions were formed by modifying the questions in the study of Bektas et al (2013). Questions were controlled by two science education expert to ensure internal validity and arranged their suggestions. Questions were administered as an exam at the end of the all presentations. Written responses were verified by the participants while controlling their paper to ensure internal validity. Questions were as follow:

Information:

a) "Light and sound",
b) "Physical and chemical changes", and
c) “Reproduction, growth, and evolution”

Please select one of the above topics and respond the following questions.

1. What are the misconceptions students may have on the topic you have chosen?
2. How do you think your students have/develop these ideas on the topic you have chosen? Please explain.

3. Select one of the misconceptions you have mentioned in question-1. In order to remove this misconception;
    a. Which instructional/teaching methods/strategies would you use while teaching the topic you have chosen? Why?
    b. Which examples/materials/activities do you use on the topic you have chosen? Why?
    c. Which evaluation techniques would you use to assess whether your students remove this misconception or not? How do you ask a question? Why?

Data analysis

Descriptive analysis, which is the one of the analysis techniques used in the qualitative studies, was used in this research (Marshall & Rossman, 2006). The researcher analyzed pre-service science teachers' written responses under three themes: knowledge of the learner (misconceptions and sources of misconceptions), knowledge of instructional strategies, and knowledge of assessment. Also, PSTs' responses to the open-ended questions were analyzed to construct coding categories suggested in the study of Bektas et al. (2013). Discussion process for the data analysis was executed with the one expert in science education and researcher and expert reached a consensus on the analysis of data. Some phrases from the written responses of participants quoted and took place in the study to confirm internal validity.

In the knowledge of learner theme, PSTs classified as high, medium, and low in terms of their scores in the questions. Maximum score of the exam was 100, but the score of these mentioned questions was 20. Hence, PSTs have the score between 14 and 20 were high scored participants. Likewise, PSTs have the score between 7 and 13 were medium scored participants and PSTs have the score between 0 and 6 were low scored participants. Therefore, the relationship between the selected topics and the score of PSTs was examined. Moreover, misconceptions that students have on selected topics were determined and listed. Finally, sources of misconceptions on selected topics based on written responses were determined as teacher, family, textbook, student, environment, the abstract/concrete structure of selected topic, materials, newspaper, TV, magazine, internet, and books.

In the knowledge of instructional strategies theme, firstly, misconceptions which PSTs select in the question-1 were determined on selected topic. Then, activities, examples, materials, and instructional strategies that PSTs used to remove this selected misconception of students on selected topic were decided.

In the knowledge of assessment theme, evaluation techniques which PSTs use to assess whether their students remove selected misconception or not were examined.

Results

This section was formed under the themes of knowledge of learner, knowledge of instructional strategies, and knowledge of assessment.

Knowledge of learner

In this part, responses of participants regarding misconceptions and sources of misconceptions on the selected topics were examined and described. Table 1 shows the selected topics by participants and their levels and gender according to selected topics. For instance, while five high scored PSTs selected the topic of "light and sound"; nine medium scored participants chose the topic of “physical and chemical changes”. Also, none of the low scored participants select the topic of “reproduction, growth, and evolution”. On the other hand, ten PSTs, 14 PSTs, and seven PSTs selected the physics, chemistry, and biology topics respectively.

Table 1. *Selected topics in terms of participant levels and gender*

Selected topics	Number of participants	Male	Female	High	Medium	Low
Light and sound	10	1	9	5	3	2
Physical and chemical changes	14	1	13	3	9	2
Reproduction, growth, and evolution	7	3	4	2	5	-
No answer	2	-	2	-	-	2
Total	33	5	28	10	17	6

Table 2 indicates that ten high, 17 medium, and four low scored PSTs selected science topics. As seen in Table 2, five high scored participants (F11, F5, M5, F4, and F7) selected the topic of “light and sound” to respond open ended questions mentioned in the data collection instrument section. Therefore, 50 % of high scored PSTs selected the physics topic. Likewise, 53 % of medium scored participants selected the chemistry topic. These were F1, F6, F12, F17, F2, F13, F22, F15, and F16. Moreover, only two low scored PSTs (F24 and F10) selected “light and sound”.

Table 2. *Selected topics in terms of participant levels*

Selected topics	High	Medium	Low
Light and sound	F11, F5, M5, F4, F7	F3, F19, F8	F24, F10
Physical and chemical changes	F27, M3, F28	F1, F6, F12, F17, F2, F13, F22, F15, F16	F20, F14
Reproduction, growth, and evolution	M2, M1	F9, M4, F18, F25, F23	-
No answer	-	-	F21, F26

Misconceptions: Participants were asked the question of “What are the misconceptions students may have on the topic you have chosen?” They responded this question by thinking 5th, 6th, 7th, and 8th grade students. Their responses were as follow:

Light and sound:

a) Light and sound spreads out in the same manner (F11)
b) Light is a matter (F11, F7, F8, F24, and F10)
c) Sound is a matter (F8)
d) Light does not spread (F7)
e) Light does not reflect (F5 and F7)
f) Light is faster than sound (M5)
g) Sound is faster than the light (F8)
h) Light and sound have the same speed (F4)
i) Sound spreads in every environment, it does not need the matter (F4)
j) Light and sound does not require the matter to spread (F4).
k) Sound spreads in the space (F8)
l) Sound spreads (F7 and F19)
m) Sound is a matter (F7)
n) Sound spreads out in space (F3)

Physical and chemical changes:

a) Melting of wax is a chemical change (F27, F28, F1, F17, F22, F16, and F20)
b) Burning of wax is a physical change (F22, F20, and F14)
c) Each color changes is a chemical change (F27, F6, F13, F15, and F20)
d) Rusting of iron is a physical change (F27)
e) Paper tear is a chemical change (M3, F2, F13, and F15)
f) When sugar dissolves in tea, it melts (F28 and F1)
g) When sugar dissolves in tea, it disappears (F1)
h) Dissolution of sugar in water is a chemical change (F17)
i) Melting and dissolution is the same (F1)
j) Rust is caused by the decay of the iron atom (F1)

Irrelevant answer: F12 gave irrelevant answer for this question.

Reproduction, growth, and evolution:

a) Growth and evolution is the same (M2, M1, F9, M4, and F23)
b) Growth occurs human aging (M2)
c) Cell numbers of large living species (elephant) is more than a small one (worm) (F25)
d) Reproduction occurs only in mammals (M2)
e) Reproduction occurs in every living species (M4)
f) Reproduction occurs between only two living species (M4)
g) Reproduction occurs only within the body (M1)
h) Reproduction happens in the same way in every living (F18)
i) The evolution would be up to a certain period of life (M2 and F23)
j) Mitosis and meiosis continues throughout life (M1)

Sources of misconceptions: PSTs were asked the question of "How do you think your students have/develop these misconceptions on the topic you have chosen? Please explain. Their written responses were as follow:

Light and sound: The most written response was the teacher (six PSTs) as a source of misconceptions on the topic of light and sound. For instance, F11 stated that *"Teacher should draw on the board the spread of light and students see this drawing on the board. However, teachers only explain as a verbal how to spread the light in the class"*.

a) Teacher (F11, F4, F3, F19, F24, and F10)
b) Family (F11 and F3)
c) Textbook (F4 and F24)
d) Student (preconceptions) (F7and F24)
e) Environment (daily life, friend, etc.) (F3, F19, and F8)
f) The abstract/concrete structure of light and sound concepts (M5)

Physical and chemical changes: The most written responses were the teacher (ten PSTs) and students (ten PSTs) as a source of misconceptions on the topic of physical and chemical changes. While many participant only state the sources of misconceptions, some of them explained why these sources create misconceptions. For instance, F17 mentioned that *"students do not listen carefully their teachers and have an environment leading to misconceptions. Also, they read newspaper and watch TV causing misconceptions"*.

a) Teacher (F27, M3, F1, F6, F2, F13, F22, F15, F16, and F14)
b) Textbook (F27)
c) Student (preconceptions) (F27, F5, M3, F1, F6, F12, F17, F2, F16, and F20)
d) Family (F1, F6, and F15)
e) Environment (daily life, friend, etc.) (F28, F1, F6, F17, F2, F15, and F16)
f) Newspaper, TV, magazine, internet (F17 and F16)
g) Materials (F2)

Reproduction, growth, and evolution: The most written response was the environment (four PSTs) as a source of misconceptions on this topic. M4 and F25 thought teachers as a source of misconceptions in this topic. For instance, M4 stated that *"Teachers use lecturing in the class and say that growth and evolution is the same. I mean, teachers have insufficient knowledge on this topic"*.

a) Teacher (M4 and F25)
b) Environment (daily life, friend, etc.) (M2, F9, F18, and F23)
c) Student (preconceptions) (M1, F18, and F25)
d) Family (F18)
e) Books (F25)

Knowledge of instructional strategies of selected topics

For this theme, PSTs were asked two questions (3a and 3b) as explained in the data collection instrument section. They answered those questions to remove one misconception which you select on selected topics from their students. Table 3 states that PSTs used which instructional strategies and examples/activities/materials to remove one misconception that their students may have on the physics topic.

Table 3. *Instructional strategies and examples/activities/materials for the light and sound*

Misconception	Participants	Instructional strategy	Examples/activities/materials
Light is a matter	F11	5E learning cycle model (exploration stage)	Using torch
	F10	Discussion	Lecturing with torch
Light does not reflect	F5	Demonstration	Analogy (playing tennis)
Light is faster than sound	M5	Traditional instruction (lecturing)	Using videos about light and sound rate
Sound spreads in every environment, it does not need the matter	F4	5E learning cycle model (exploration stage)	Activity with the alarm clock, bell jar, and lamp
Light does not spread	F7	Demonstration	Using torch
Sound spreads out in space	F3	Discussion	Asking questions and doing discuss about the movement of sound/torch
Irrelevant answer	F19, F8, and F24		

All of them stated that they use instructional strategy to remove misconception from students on the light and sound. However, they cannot explain in detail how to use these strategies in their lesson. For instance, F5 stressed that *"My students do experiment in the class. I filled water in the glass and students throw stone in this glass. They observe events"*.

Table 4 indicates that PSTs used which instructional strategies and examples/activities/materials to remove one misconception that their students may have on the chemistry topic. Participants did not explain in detail how to use these strategies. For instance, F27 mentioned that *"I use demonstration and show the melting of wax. Students see this event and students remain in their mind"*.

Table 4. *Instructional strategies and examples/activities/materials for the physical and chemical changes*

Misconception	Participants	Instructional strategy	Examples/activities/materials
Melting of wax is a chemical change/ Burning of wax is a physical change	F27	Demonstration	Melting of wax experiment/wax and lighter
	F28	Demonstration	Lecturing/wax, lighter
	F1	Demonstration	Burning/melting of wax experiment/videos
	F22	Demonstration	Melting of wax experiment/wax and lighter
Paper tear is a chemical change	M3	Experiment based on demonstration	Activity with paper and scissors
	F2	Traditional instruction	Activity with paper, scissors, and lighter
	F13	Inquiry	Activity with paper, scissors, and lighter
	F15	Lecturing-Traditional instruction	Paper/Scissors
Each color change is a chemical change	F6	Experimentation	Activity with swab and juice
Dissolution of sugar in water is a chemical change	F17	Traditional instruction	Lecturing
Irrelevant answer	F12, F16, F20, and F14		

Table 5 indicates that PSTs used which instructional strategies and examples/activities/materials to remove one misconception that their students may have on the biology topic. All participants preferred teacher centered instruction to remove misconception of students on this topic. M1 and M4 said that they use role-playing technique, but their explanations were not adequate in terms of removal of misconceptions.

Table 5. *Instructional strategies and examples/activities/materials for the reproduction, growth, and evolution*

Misconception	Participants	Instructional strategy	Examples/activities/materials
Growth and evolution is the same	M2	Traditional instruction	Lecturing
	M1	Lecturing-role playing technique	Ruler
	F9	Lecturing-demonstration-	Animation (video)
	M4	Lecturing -role playing technique	Using two students (tall and short) in the same age
	F23	Traditional instruction	Lecturing
Irrelevant answer	F18, and F25		

Knowledge of assessment of selected topics

For this theme, PSTs were asked the question of "Which evaluation techniques would you use to assess whether your students remove one misconception on selected topic or not? How do you ask a question? Why?" and they answered for the physics topic as seen in Table 6. For instance, F11 stated that she would use open ended question to remove misconception (light is a matter) from her students and she would ask the question of "Is the light matter? Why?" in her exam. F19, F8, F24, F10, and F7 did not give answer for this question.

Table 6. *Evaluation techniques for the light and sound*

Misconception	Participants	Evaluation technique	Question
Light is a matter	F11	Open ended questions	Is the light matter? Why?
	F10	Open ended questions	No answer
Light does not reflect	F5	Open ended questions	Does the light reflect? Why?
Light is faster than sound	M5	Open ended questions	Does the light is faster than the sound? Why?
Sound spreads in every environment, it does not need the matter	F4	Open ended questions	Can light and sound spread in any environment? Give examples.
Light does not spread	F7	No answer	No answer
Sound spreads out in space	F3	Open ended questions	How does the light spread?

PSTs answered evaluation techniques and their questions for the chemistry topic as seen in Table 7. For instance, F2 stated that she would use true/false questions to remove misconception (Paper tear is a chemical change) from her students and she would ask the questions of "1-Paper tear is a chemical change; 2- Burning of paper is a physical change" in her chemistry exam. F12, F16, F20, F14, F1, F15, and F17 did not give any response for this question 3c.

Table 7. *Evaluation techniques for the physical and chemical changes*

Misconception	Participants	Evaluation technique	Question
Melting of wax is a chemical change/	F27	Open ended questions	Is the melting of wax a chemical or physical change? Why?
Burning of wax is a physical change	F28	Open ended questions	What do you think that how does the burning of wax a change?
	F1	Open ended questions	No answer
	F22	Open ended questions	Can you give examples about physical and chemical changes? Why are your examples physical or chemical changes?
Paper tear is a chemical change	M3	Open ended questions	How does the paper tear a change? Is it physical or chemical? Why?
	F2	True/False questions	1-Paper tear is a chemical change; 2- Burning of paper is a physical change
	F13	Multiple choice question	Which of the following is a chemical change? There are no options
	F15	No answer	No answer
Each color change is a chemical change	F6	Open ended questions	Is each color changing a chemical change? Why?
Dissolution of sugar in water is a chemical change	F17	No answer	No answer

PSTs answered evaluation techniques and their questions for the selected biology topic as seen in Table 8. For instance, M2 stated that he would use open ended questions to remove misconception (Growth and evolution is the same) from his students and he would ask the question of “Is the growth and evolution same concepts? Why?” in his biology exam. F18, F25, M1, F9, M4, and F23 did not give any response for this question 3c.

Table 8.*Evaluation techniques for the reproduction, growth, and evolution*

Misconception	Participants	Evaluation technique	Question
Growth and evolution is the same	M2	Open ended questions	Is the growth and evolution same concepts? Why?
	M1	True/False questions	No answer
	F9	Open ended, T/F, multiple choice, fill in the blanks (no question)	No answer
	M4	No answer	No answer
	F23	T/F, fill in the blanks	No answer

Conclusion and Discussion

The purpose of the study was to explore pre-service science teachers’ pedagogical content knowledge in the physics, chemistry, and biology topics. This research study contributes to the development of pre-service science teachers’ understanding of science topics. The understanding of science topics has a crucial role for the pre-service science teachers; however, the result of previous studies indicated that PSTs had inadequate understanding on the science topics (e.g. Tekkaya, Cakiroglu, & Ozkan, 2004). In this study, PSTs had insufficient information on instructional strategies and knowledge of assessment in selected topics.

However, it was seen that PSTs have sufficient information in terms of knowledge of learners in the above-mentioned topics. The most selected topic by PSTs is the physical and chemical changes. While 14 PSTs selected the chemistry topic, only seven PSTs selected the biology topic. On the other hand, five of ten high scored PSTs selected the light and sound to respond the questions. Moreover, medium scored PSTs preferred the topic of physical and chemical changes (9 out of 17). It can be concluded that high scored participants preferred physics topic since this topic is more abstract than other topics.

Many of the participants (30 out of 33) wrote about misconceptions of students for their selected topics. Thus, ten PSTs mentioned about 14 misconceptions found in the literature for the physics topic. Likewise, 13 participants wrote regarding ten misconceptions students may have on the physical and chemical changes and seven PSTs mentioned about ten misconceptions on the topic of biology. However, the number of misconceptions on the chemistry and biology topics was quite a few as the findings of Berg and Brouwer (1991) in the physics topics and Hashweh (1987) in the physics and biology topics. Halim and Meerah (2002) mentioned that teachers who gave incorrect scientific answers were less likely to be aware of students’ misconceptions. Therefore, it can be said that PSTs were inadequate while stating misconceptions on the chemistry and biology topics. The results indicated that pre-service science teachers’ knowledge about students’ misconceptions of the selected science topics might develop with the teaching experience (Bektas et al., 2013).

Most of the PSTs were aware of the sources of learners’ misconceptions on the topic they have chosen. Participants in this study stressed teachers, family, textbooks, students’ prior experience, environment, abstract structure of the topics, newspaper, TV, magazine, internet, and materials as sources of misconceptions students may have on the selected topics. This finding is consistent with the sources proposed by Bektas et al., (2013) and Sahin and Koksal (2010). Six PSTs who select the physics topic thought teachers as a source of misconceptions and only two PSTs who select the physics topic mentioned student as a source of misconceptions. However, ten PSTs who select the chemistry topic and three PSTs who select the biology topic wrote students as a source of misconceptions. Thus, it can be concluded that if PSTs see teachers as a source of misconceptions, they can improve themselves in the future to make effective instruction.

Based on findings, majority of the participants possessed some difficulties in teaching selected topics in order to overcome misconceptions. Although some of them stated that they would use 5E learning cycle model, demonstration, discussion, and inquiry which are constructivist teaching strategies, they were unsuccessful while explaining how to use these strategies. This result is consistent with the result of studies conducted by Bektas et al (2013) and Halim and Meerah (2002). Hence, it can be concluded that they had insufficient PCK in terms of knowledge of instructional strategies. As shown in previous study conducted by Hashweh (1987), teachers proposed teaching strategies or materials that reinforced misconceptions in students when they lack of information about the instructional strategy and content knowledge on science topics. In the same way, Clermont, Borko, and Krajcik (1994) explored novice chemistry teachers' knowledge of demonstrations. The participants were presented videotapes that represent positive and negative sides of the demonstrations of density and air pressure. The researchers stated that novice teachers were unaware of the complexity of demonstrations and they did not know that the presented demonstrations might produce confusion among middle school students. Thus, the development of PCK is vital for science teachers who have difficulties in the understanding of instructional strategies.

Majority of the participants possessed some difficulties in assessing whether their students remove misconception on selected topic or not. In fact, 11 PSTs only stated that they would use open ended questions to remove misconceptions on selected topics. Thus, it can be concluded that PSTs had insufficient knowledge of assessment techniques on selected science topics. However, if PSTs have adequate teaching experience over time and overcome their own misconceptions, they could eventually develop their knowledge of assessment (Halim and Meerah, 2002).

As a conclusion, this study suggests that pre-service science teachers' PCK is a necessary for their future science teaching since teachers have sufficient PCK can give content to their students in a reasonable way and prevent students from having misconceptions. In other words, PCK is a way of effective science teaching (Abell, 2008; Kind, 2009; Schulman, 1987).

Recommendations

Although this study is related to pre-service science teachers' pedagogical content knowledge in the physics, chemistry, and biology topics, further research is needed to explore pre-service science teachers' pedagogical content knowledge in the all science topics. Furthermore, the current study did not reflect all components of PCK in Magnusson et al. (1999)'s model. Further studies focusing on all PCK components are necessary.

Science teacher education programs should highlight instructional strategies in order to improve pre-service science teachers' PCK within specific science topics. Also, science teacher education programs should raise awareness regarding misconceptions of science topics and sources of these misconceptions so that pre-service science teachers may design their teaching considering students' possible misconceptions in these topics and its' sources in the future. Pre-service science teachers should be given opportunities to assess their students' understanding of science topics in placement schools.

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