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Use of Pedagogical Content Knowledge in Teaching Chemistry in Early Science Education

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The purpose of this research was to explore the pedagogical content knowledge of prospective primary school teachers on the subject of phase transitions of matter consisting sample of 41 prospective primary school teachers. Content knowledge test, pedagogical knowledge questionnaire and semi-structured interview were used to collect data. This study showed that primary student teachers had various problems related to the phase transitions of matter as well as teaching. The main problems of student teachers were insufficient content knowledge, misconceptions and lack of knowledge about instructional strategies, assessment and evaluation. The results of this study impressed that prospective primary school teachers had different methods of using technology for teaching about the phase transitions of matter. This study proposes some pedagogical implications for teacher education.

Key Words: Pedagogical content knowledge, Prospective primary teacher education, Phase transitions of matter.

INTRODUCTION

Many studies have been focused on pre-service teachers' conceptions of teaching or learning science topics; ideas on and attitudes toward science in different countries[1-4]. The results showed that pre-service teachers had various misconceptions and lack of knowledge on science topics.

Pedagogical content knowledge has been defined by Shulman[5,6] as teachers ways of representing and formulating the subject-matter knowledge in the context of facilitating student learning. Grossman[7] concluded the components of pedagogical content knowledge as subject matter knowledge, general pedagogical knowledge and contextual knowledge.

Many researchers[1,8-11] have investigated the preservice teachers pedagogical content knowledge in science topics. The researchers have generally found that the preservice teachers did not have necessary pedagogical content knowledge to teach science effectively in these studies. Teaching experiences and teacher's thinking have reported as the components of effective teaching in recent years[8,12,13]. Abd-El-Khalick[4], concluded that that the role of teaching experience in developing teachers' pedagogical content knowledge should be emphasized and incorporated into theorizing the construct of pedagogical content knowledge. In addition, some researchers[19] revealed that there was a significant relationship between subject matter knowledge and pedagogical content knowledge.

Teacher's thinking has been the focus of the research studies that report the components of effective teaching in recent years[8,12-14]. The field of teacher's thinking contains teacher's practical knowledge and others[13,14].

There are some pedagogical content knowledge studies about science/chemistry topics in recent years. For example, Van Driel *et al.*[15] emphasized that teaching experience was the main source of pedagogical content knowledge but subject matter knowledge was the prerequisite of pedagogical content knowledge about the topic of chemical equilibrium. In other study, De Jong *et al.*[16] showed that a special education program related to pedagogical content knowledge. Most of the chemistry teaching master students had started to think deeper about students' understanding difficulties for particulate nature of matter. Van Driel *et al.*[11] argued that the changes observed in 12 chemistry student teachers' pedagogical content knowledge might come from the differences related to student teachers' subject matter knowledge in a similar study. De Jong *et al.*[17] stated that macro, micro and symbolic meanings related to chemistry topics caused to develop 8 chemistry student teachers pedagogical content knowledge. Similarly, De Jong[18] developed a special transferring learning from teaching program to increase the student teacher's pedagogical content knowledge in a course.

Significance and aims of the study: Prospective primary school teacher's pedagogical content knowledge on the topic of phase transitions of matter was investigated in order to provide a better foundation for primary teacher training program.

There is no clear finding related to the content knowledge and pedagogical content knowledge of prospective primary school teacher in the literature. Moreover, it was not encountered any findings about prospective primary school teachers pedagogical content knowledge in the topic of phase transitions of matter. So, the results of this study will make significant contributions to the prospective primary school teachers pedagogical content knowledge in the literature. It is believed that this study will help to promote the quality of primary teachers.

The study focused on finding out: (1) What is the prospective primary school teachers content knowledge about states of matter? (2) What is the prospective primary school teachers pedagogical content knowledge including knowledge of student learning, knowledge of curriculum, knowledge of instructional strategies and representations?

EXPERIMENTAL

The forty one participants have been selected amongst 2nd year students enrolled in the department of primary education, in the 2009 academic years. The average age of the student teachers 20.6 years. They have different amount of subject matter knowledge, other factors are almost the same. The student teachers had general chemistry lesson before and participated to this study after this lesson.

The current study was conducted on the basis of three main components of pedagogical content knowledge proposed by Shulman[5] revised by Magnusson *et al.*[19]. These main components can be listed as knowledge of student learning, knowledge of curriculum, knowledge of instructional strategies and representations.

Data collection instruments

Content knowledge test: Prospective primary school teachers content knowledge on the topic of states of matter was determined by a fifteen-question multiple-choice test. The test was based on the relevant literature[20-23]. This test was prepared to evaluate the prospective primary school teachers own understanding of phase transitions of matter and their ideas of students prior knowledge, alternative conceptions and learning difficulties within the topic. All of the questions were examined and evaluated by three experts in the area (a chemist, a chemistry educator and a science educator) to validate test and the alpha reliability coefficient of the test was 0.84.

Pedagogical knowledge questionnaire: The questionnaire was based on the literature[24] and consisted of four open ended questions. The aim was to investigate pedagogical knowledge of prospective primary school teachers. These questions were about knowledge of student learning, knowledge of curriculum, knowledge of instructional strategies and representations of using technology for teaching on the phase transitions of matter.

Semi-structured interviews: A semi-structured individual interview was administered in order to explore the prospective primary school teachers pedagogical knowledge on states of matter. Interview questions were developed and based on the review of relevant literature[25]. The interview questions were based on the three components of knowledge of student learning, knowledge of curriculum, knowledge of instructional strategies and representations.

The interviews were conducted with 10 randomly selected prospective primary school teachers (6 females, 4 males) and lasted about 20-30 min. Different categories used in order to explore prospective primary school teachers pedagogical knowledge on phase transitions of matter based on the literature[25].

Analysis of data: The student teachers' knowledge about properties related to states of matter was collected and analyzed by content knowledge test and semi-structured interviews. The primary purpose here was to find out whether the student teachers knowledge about properties related to states of matter was scientifically correct or not. Three categories were formed with respect to their understandings[25].

Scientific view: The student teachers who can describe knowledge about properties related to states of matter scientifically correct were in this category.

Deficient view: The student teachers who describe knowledge about properties related to states of matter with misconception were in this category.

Wrong view: The student teachers who had wrong answers completely were in this category.

Data evaluation for questionnaire and semi-structured interviews was done using two independent raters. The percentage agreement between the two raters was roughly 92 %.

RESULTS AND DISCUSSION

Student teachers' content knowledge

Knowledge about properties related to states of matter: One of the questions about states of matter was, what is the reason of ice and chocolate becoming liquid when heated? 22 of 41 student teachers answered correctly this question as follows:

The reason of ice and chocolate becoming liquid when heated is expansion of matter by heating.

On the other hand 15 student teachers had deficient answers as decreasing density when ice and chocolate heated as a reason and 4 student teachers in the wrong view category reasoned that liquid formed by the reaction with oxygen gas. This result showed that almost more than half of student teachers (54 percentages had scientific views and the rest of student teachers had deficient or wrong view as can be seen from Table-1.

TABLE-1
NUMBERS AND PERCENTAGES OF ANSWERS TO QUESTIONS RELATED KNOWLEDGE ABOUT PROPERTIES RELATED TO PHASES OF MATTER

Question	Understanding categories		
	Scientific view	Deficient view	Wrong view
Solid turns to liquid when heated	22 (54)	15 (36)	4 (10)
Reason of gas expansion when heated	18 (44)	20 (49)	3 (7)
Change in the irregularity of matter	10 (24)	21 (52)	10 (24)
Heat exchange during change of state and change in irregularity	18 (44)	22 (54)	1 (2)
Mean	17 (41)	20 (49)	4 (10)

Change of state, temperatures of change of state and vapour pressure: The student teachers content knowledge about change of state, temperatures of change of state and vapour pressure was collected and analyzed by content knowledge test and semi-structured interviews. The purpose was to find out whether the student teachers knowledge about change of state, temperatures of change of state and vapour pressure was scientifically correct or not. Based on their understanding, three categories used above were adapted to this area of knowledge and applied.

The first question was, what are the constant and variable quantities during change of state for pure matters? Only two student teachers answered correctly as follows:

The constant quantities are mass and temperature while variable ones are volume and density. The rest of the participants (39 of 41) had all confused the constant and variable quantities during change of state for pure matters. Table-2 shows that 95 percentages of student teachers had deficient or wrong view about variable and constant quantities during change of state.

TABLE-2
NUMBERS (PERCENTAGES) OF ANSWERS TO QUESTIONS RELATED KNOWLEDGE ABOUT CHANGE OF STATE, CHANGE OF STATE TEMPERATURES AND VAPOUR PRESSURE

Question	Understanding categories		
	Scientific view	Deficient view	Wrong view
Changing and invariable properties during change of state	2 (5)	29 (71)	10 (24)
Factors affecting temperature and duration of change of state	16 (39)	20(49)	5 (12)
Factors affecting vapour pressure of liquids during change of state	5 (12)	22 (54)	14 (34)
Mean	8 (20)	23 (56)	10(24)

The second question was about factors affecting temperature and duration of change of state for pure matters. Sixteen student teachers answered correctly and stated that decreasing amount of matter does not affect freezing point but decreases the time of freezing. Twenty student teachers had deficient view and answered this question correct partly. For example, some of them stated that decreasing amount of matter does not affect freezing point and the time of freezing, while others answered that decreasing amount of matter does not affect freezing point but increases the time of freezing. Five participants had wrong view as follows: Decreasing amount of matter decreases freezing point and the time of freezing.

These results showed that more than half of participants had deficient or wrong view about the factors affecting temperature and duration of change of state for pure matters as can be seen from Table-2.

The last question was about factors affecting vapour pressure of liquids during change of state. Five student teachers had scientific view and they had scientific information that vapour pressure of a pure substance depends on temperature but not other factors such as mass, volume *etc*. On the other hand, 36 student teachers had deficient or wrong view related to a question about factors affecting vapour pressure of liquids during change of state (Table-2). The participants who had deficient views thought increasing vapour pressure by evaporating liquid at constant temperature and the student teachers in the wrong view category had completely wrong conceptual knowledge about factors affecting vapour pressure.

Understanding the connection of heat and temperature in change of state diagrams: Understanding the connection of heat and temperature in change of state diagrams was analyzed using the content knowledge test and semi-structured interviews. Two categories were formed related to the results of content knowledge test and evaluation of the interviews. The previous four categories of understanding were not used here because there are only two cases such as understanding the connection of heat and temperature in change of state diagrams or not.

The connection between heat and temperature in change of state diagrams is understood. They had understood at least one of the following facts: (a) the temperature remains constant during a pure matter changes state; (b) heat increases with increasing heat and decreases with decreasing heat; (c) kinetic energy is proportional with temperature and potential energy increases with increasing heat and decreases with decreasing heat; (d) latent of heat and specific heat can be found using data in change of state diagrams.

The connection between heat and temperature in change of state diagrams is not understood. If none of these were mentioned. As can be seen from Table-3, 34 % of student teachers had correct answer scientifically about determining type of matter (like pure water, salt water and from the heat-temperature diagrams and the rest of student teachers could not interpreted heat-temperature diagrams scientifically and not understood the connection between heat and temperature.

TABLE-3
NUMBERS (PERCENTAGES) OF ANSWERS TO QUESTIONS RELATED UNDERSTANDING CATEGORIES ABOUT THE CONNECTION BETWEEN HEAT AND TEMPERATURE IN CHANGE OF STATE DIAGRAMS

Question	Understanding	Categories
	Connection between heat and temperature is understood	Connection between heat and temperature is not understood
Determining type of matter related to the connection between heat and temperature in change of state diagrams	14 (34)	27 (66)
Change in kinetic and potential energy related to temperature in change of state diagrams	20 (49)	21 (51)
Determining latent of heat and specific heat by interpreting change of state diagrams	8(20)	33 (80)
Mean	14 (34)	27 (66)

All of 49 percentages of student teachers had understood the relation between heat and temperature since they had correct answers about changing kinetic or potential energy related to heat-temperature diagrams by evaluating their answers in the interview and answers given to the questions in content knowledge test. On the other hand, more than half of the student teachers could not understand the connection between heat and temperature (Table-3).

Only 20 % of participants had understood the connection between heat and temperature because they interpreted heat-temperature diagrams correctly and determined latent of heat and specific heat from data. However, 80 % of them had not understood the relation between heat and temperature since they determined latent of heat and specific heat from data in a wrong way as can be seen from Table-3.

Prospective primary school teachers pedagogical knowledge: The results from pedagogical knowledge questionnaire and interviews are as follows: There were four multiple choice questions to investigate pedagogical knowledge of prospective primary school teachers based on the literature[24].

The first question was Mr. Aydin is a 5th grade teacher. One of his objectives is for students to learn at a simple level about the relationship between the states of matter. He started the lesson by showing an overhead transparency of the states of matter, naming phases and labeling them as shown. Which one of the following is the best evaluation of the lesson so far? 27 % of prospective primary school teachers have answered this question as this is a good lesson so far, because the teacher is clearly and systematically introducing the vocabulary that the children will need for further studies about states of matter. Thirty two percentages of the student teachers have chosen the answer. This is a good lesson so far, because by learning the examples of the states of matter, the students are more engaged and will ask appropriate questions about their properties. Nine percentages of prospective primary school teachers have preferred the answer as this lesson is not off to a good start, because it begins with the teacher giving the children information about states of matter, before any attempt to develop a sense of questioning or investigation on the part of the students (desired response). Twelve percentages of participants had answers for his question as the lesson is not off to a good start, simply because it begins with the teacher doing the talking, which is never a good idea. The rest of the student teachers (20 %) answered this question as this lesson is not off to a good start, because the students are not doing anything hands-on. There should always be real states of matter for students to observe, so they would connect the lesson to the real world.

The second question was a useful activity for teaching states of matter is to give students a piece of ice. They can classify it as a solid. Let it heat, melt and they can reclassify it as a liquid. Boil it away. They can then call it a gas. The goal is that student's gain a conceptual understanding of the same matter can be in all three states and the relationship between states of matter. Five teachers have five different lesson plans for using this activity to teach the relationship between states of matter. Which plan would be the best? The answers of prospective primary school teachers to this question and their percentages were as follows:

Mr. Tekin starts by writing a top of the board: States of matter and dictates the properties of the phases for students to write them. He then explains the properties of the phases and shows it with a table. He gives students the opportunity to ask questions at any stage. Finally he has students verify the properties of phases experimentally by checking what happens to a piece of ice when heated (12 %).

Ms. Yildirim first has students explore what happens to the ice when heated and asks them to describe the three states of matter that result. She focuses on the question of how states of matter might be related and then asks for suggestions for physical change that would describe their observations. Having put forward a physical change, students then test it by making predictions in various situations and trying out. They finally write their own statements about the states of matter and properties they have generated (17 %). This answer was the desired response.

Mr. Dogan gives students freedom to try out anything they wish with the ice, intending that they should be drawn in to the hands-on activity and discover on their own the relation between the states of matter. He does not impose structure nor tell students what to do, but is available for discussion, in which he does not give 'answers' to questions but instead asks questions in return. At the end of the session he does not provide the 'correct' relationship between states, since the point is for students to discover their own (4 %).

Ms. Demirci, as an introduction to the states of matter, defines the term state and has students write it down. She then explains the concept carefully with examples. Thereafter she presents the states of matter in the form 'relationship between states of matter. Students then verify the relationship between states of matter by doing the hands-on ice activity (43 %).

Mr. Zengin feels that the textbook treats states of matter on clearly and correctly. Thus he has several students in succession read paragraphs aloud from the book and encourages students to ask if they don't understand something. He then demonstrates the states of matter for the whole class with the ice activity and two students assisting, to verify the textbook statement (24 %).

The third question was five teachers have five different methods of assessment and evaluation on the topic of the states of matter. Which one of the following is the best assessment and evaluation method for the 5th grade students about the topic of states of matter?

Forty seven percentages of participants have chosen the answer as Mr. Akin uses only multiple choice test after the subject is taught.

Twenty three percentages of prospective primary school teachers preferred the choice as Mr. Yaman prefers quizzes before and after every lesson about the states of matter.

Eleven percentages of student teachers had choice for this question as Mr. Deniz prepares a portfolio assessment for every student and uses process based evaluation. (desired response)

Sixteen percentages of them have chosen the statement as Mrs. Esen prefers to use different types of learning assessment instruments together after the subject is taught. For example, she prepares questions about the states of matter such as open-ended questions, concept map, true-false items and multiple choice questions.

The rest of the participants have answered this question as Mrs. Çelik uses only open-ended questions after the subject is taught.

The last question was five teachers have five different methods of using technology for teaching about the states of matter. Which one of the following is the best method of using technology for teaching the states of matter.

(a) Mr. Oran prefers to teach the topic by using slide projector and overhead projector (42 %). (b) Mr. Silier prefers to teach the subject by using computer-aided instruction (17 %). (c) Mr. Akyol prefers using demonstrated experiments in TV to teach the subject (26 %). (d) Ms. Çetin prefers to teach the topic by using web-based instruction (11 %). (e) Ms. Öztas prefers to teach the subject by using simulating experiments (4 %).

Results from interviews

Knowledge on student learning and conceptual difficulties of the students: Prospective primary school teachers knowledge on the learning and conceptual difficulties of students related to states of matter was investigated by using their answers in the semi-structured interviews. The answers were classified as follows: (i) students think that temperature changes during change of state for pure matter; (ii) students think that mass does not remain constant during change of state; (iii) students believe that particles are stable in solid phase and dynamic in liquid or gas phase; (iv) students think volume of water increases during ice melts; (v) students think that change of state is chemical change if it is irreversible.

Student teachers did not realize any conceptual difficulties that students might face when studying states of matters. Thinking about the possible difficulties of students was very difficult for student teachers according to the answers. Fifteen of 41 student teachers had told that they realized one of the conceptual difficulties explained above that student might face; five of 41 student teachers said that they realized two of the conceptual difficulties and finally only one of the student teacher explained that he realized three of the conceptual difficulties.

Majority of student teachers argued that students perceived the events discrete in terms of particulate nature of matter and heat-temperature change during change of state. Only 5 participants realized that students thought decreasing mass of a matter when heated during change of state. In addition, 4 student teachers realized that some students perceived change of state as chemical change if it is irreversible. None of the student teachers realized students' conceptual difficulties about vapour pressure related to amount of matter and altitude.

Main teaching goals (knowledge on curriculum): Prospective primary school teachers interviews and questionnaire were used to analyze The main teaching goals (knowledge on curriculum). The following categories were formed:

Comparison of properties related with states of matter: This category included all properties related with states of matter and comparison of these properties.

Change of state: Student teachers concentrate on change of stat e, particulate nature of matter and how heat and temperature change during change of state.

The core content: The student teachers explained some core content like solid, liquid and gas states of matter.

No answer: They could not explain the most essential content to teach.

Twelve student teachers emphasized properties about states of matter and comparison of these properties. More than half of these participants mentioned that they aimed comparison of states supported by activities and daily life examples. Ten student teachers argued the events during change of state by explaining and giving examples at microscopic and macroscopic level as a main teaching goal. Besides, 15 student teachers explained core contents like solid, liquid and gas states of matter. Ten of 15 student teachers proposed the gas state of matter especially and explained that the experiments and activities should be done to concrete the concepts. Four participants could not mention the most essential content to teach.

Teaching methods (knowledge of instructional activities): The prospective primary school teachers instructional activities were studied through both the questionnaire and the semi-structured interviews. The instructional activitie collected first and then similarities and differences were examined. Finally, instructional activities were collected in five different categories as experimental work, making observation, drama, teaching by games and group working. Some of the student teachers concentrated on only one activity, while some of them proposed more than one activity. Primary student teachers chose the following activities (Table-4).

TABLE 4
ACTIVITES CHOSEN BY PRIMARY STUDENT TEACHERS FOR TEACHING PHASES OF MATTERS TO FIFTH GRADERS

Preferred activities	Numbers of student teachers (percentages)
Experimental work	18 (44)
Making observation	15 (36)
Drama	27 (66)
Group working	25 (61)
Teaching by games	22 (54)

Orientation to teaching (knowledge on instructional strategies and representations): Questionnaire and semi-structured interviews were used to analyze prospective primary school teachers orientation to teaching and the teaching orientations were classified by two categories proposed by Adams and Krockover[26].

(a) Constructivist teaching orientation is an approach that the teacher transmits understanding of key ideas, leads students to reconstruct their ideas, use of student-centered teaching methods[27,28]. An example of one lesson description classified as constructivist is as follows:

First lesson: Teacher asks students' prior knowledge. Next, a group of students are asked to heat a pure matter and the other groups of students are asked to heat a mixture. They are asked to observe change in temperature during change of state and compare the macroscopic properties during change of state as group discussion. Teacher encourages the students to describe their views.

Second lesson: Students weigh part of ice and measure the temperature by using thermometer. Then, students melt ice and measure the weigh and mass again. They continue to heat and repeat the same measures for gas state. The students debate the comparison of all these states of matter. The discussion is finished by a concept map on the blackboard and students make notes.

(b) Conceptual teaching orientation is an approach that teaching concentrates on transmitting correct scientific ideas by use of teacher-centered methods, cookbook investigations[19,27-29]. An example of one lesson description classified as conceptual is as follows:

First lesson: Teacher motivates the students about the lesson and asks questions about properties related to states of matter to discuss. Teacher draws a diagram about the conversion of states on the blackboard and asks new questions about this conversion. He/she answers the questions from students related to the topic and corrects the false responses immediately. A short film about the subject was watched and provided students to repeat the topic. Students discuss the properties about states of matter in small groups.

Second lesson: Students start to study about change of state and make research about the subject from textbooks and other source materials, activities, experiments and demonstrations. Teacher gives information how to work and arranges materials for the students. Finally, students introduce and discuss their findings to others.

Primary student teachers had mostly preferred constructivist teaching approach (23 student teachers). 10 student teachers used conceptual approach as a teaching orientation. Furthermore, 8 participants used synthesis of the two approaches. It could be thought for student teachers to be in the transition state between two approaches.

The present study showed that primary student teachers had various problems when looking at the states of matter and teaching. The characteristic problems of these teachers were insufficient subject matter knowledge, misconceptions, lack of knowledge about instructional strategies, assessment and evaluation and students' understanding of science. These results are similar to Ekborg's[30] study of student teachers' partial understanding with misconceptions and supported with the findings of Hashweh[31] and Smith & Neale[29].

The results of this study impressed that prospective primary school teachers had different methods of using technology for teaching about the states of matter. The most common technologies preferred by prospective primary school teacher were slide projector and overhead projector; demonstrated experiments in TV to teach the subject; computer-aided instruction; web-based instruction and simulating experiments in order. Primary student teachers were not conscious of students' conceptual difficulties about states of matter. It is very difficult for a primary student teacher to realize student misconceptions since he/she has own misconceptions. Student teachers having inadequate subject matter knowledge and misconceptions may transmit their own misconceptions to their students[31-33].

Student teachers' orientation to teaching was related to their own educational background. Primary student teachers argued constructivist teaching orientation and student-centered learning. The reasons of this choice might be that they hide their weaker subject matter knowledge and activity based teaching orientation might also be expressed by concealment of weak subject matter knowledge. This is similar to the finding of Gess-Newsome and Lederman[34]. On the other hand, this result is contrary to the findings of Carlsen[35] and Sanders *et al.*[36]. The current study introduced that primary student teachers were more constructivist but were less aware of students' misconceptions and various teaching methods. This result is contrary to the findings of Hashweh[37].

The most common educational need of student teachers was subject matter knowledge and followed by knowledge of instructional methods; assessment and evaluation. This result is consistent with the findings of Adams and Krockover[26]. In their study. The primary student teachers felt unconfident about their subject matter knowledge. Adams and Krockover[26] indicated that primary student teachers also had deficiencies about knowledge of students' understanding, knowledge of curriculum of science and teaching experience and observing science teaching in the primary school.

Implications for teacher education: Characteristic models of pedagogical content knowledge are not used in teacher training since pedagogical content knowledge develops through teaching experience. Pedagogical content knowledge researches should be simple and practical enough and help to provide guide for teachers. Subject matter knowledge representation table combining professional and pedagogical experience proposed by Loughran, Mulhall & Berry[38] and Loughran *et al.*[39] can be used in in-service training. This table consists of clarification of subject matter knowledge and reflects pedagogical knowledge of the teacher. Different teaching methods and strategies used in the same subject can develop teaching experience as impressed by Van Driel, Verloop & De Vos[11] and Hogan *et al.*[40]. This method can be used for student teachers in faculties of education and opportunities can be provided to control instructional methods, using technology in lessons and methods of assessment and evaluation. Some applications like content analysis, methods of teaching and design of teaching by using technology and applying assessment and evaluation techniques can be done. This research suggests the view that pedagogical content knowledge supported by subject matter knowledge and pedagogical knowledge should be taught during teacher training. Many teacher education programmes used pedagogical content knowledge as a central concept in their education programme in the literature[41-44].

There are various different views on the concept of pedagogical content knowledge. There is a need for more scientific studies and examples about using subject matter knowledge and pedagogical knowledge related pedagogical content knowledge in teacher education. Simple tools are needed to facilitate teacher education. Teacher education programme should consider the influence of subject matter knowledge and pedagogical knowledge on pedagogical content knowledge as a central concept. Pedagogical content knowledge researches have much potential in teacher training in the light of this study. However, it is thought that this potential cannot be revealed properly in the researches so far.

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