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Prospective Science Teachers' Subject-Matter Knowledge about Overflow Container

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Abstract
The purpose of this study was to determine prospective science teachers' subject-matter knowledge (SMK) about overflow container. This study was carried out in the form of a case study in spring term of the academic year of 2013-2014 with seven sophomore prospective science teachers who were studying at Elementary Science Teaching Department in Education Faculty in a university on the north coast of Black Sea Region in Turkey and who passed General Physics course. Interviews consisting of seven questions which were supported with a case text were used to collect data. Data obtained from the study were presented in a matrix. It was found that prospective science teachers have some alternative conceptions about overflow container and their SMK was inadequate. Furthermore, their SMK did not show difference between the upper group's participants whose GPA scores were higher than 2.50 out of 4.00 and lower group's participants whose GPA scores were lower than 2.50 out of 4.00. It was suggested that instructors should have been informed about prospective teachers' alternative conceptions and conceptions they have difficulty in learning, and they should have planned their teaching appropriately.
Keywords: buoyancy force, overflow container, pedagogical content knowledge, prospective science teachers, subject-matter knowledge

1. Introduction

Recently, distributions of information and lifelong education have been important as well as production of information to maintain the presence of societies. This is possible with teachers who have technological, up-to-date information and the ability of transferring this information (Çalık & Aytar 2013). By teacher education, teachers are expected to have content knowledge which is the combination of three categories: SMK, pedagogical content knowledge (PCK) and curriculum knowledge (CK) (Shulman 1986).

The result of literature review revealed that there are a lot of definitions for PCK and SMK. For example, according to Shulman (1986), SMK is that teachers have it for a particular area, but PCK can be used while teaching SMK. In other words, PCK is defined as an explanation to make the subject more clearly by using various techniques. CK is defined as some information about programs including some different learning activities that aim to teach a particular course for a specific grade. While Grossman (1988) defines PCK as knowledge for the student understanding, CK, teaching strategies knowledge and knowledge for teaching goals, it is resulted that CK is placed as a part of PCK. However, Shulman (1987) claimed that CK is a separate area. Cochran, DeRuiter & King (1993) claimed that a teacher's PCK develops when the teacher begins to become aware of students' learning needs. Further, Cochran *et al.* (1993) did not accept SMK as a separate component, but as a component of knowing pedagogical area. PCK is composed of SMK, knowledge about students, teaching strategies knowledge, teaching environment knowledge and knowledge for teaching goals in Fernández-Balboa & Stiehl's (1995) model. When the studies about PCK in the literature are examined, it is obviously seen that researchers do not agree on PCK's components. But in the model of Kaya (2009), SMK is appeared as a component of PCK as in Shulman's (1987) model.

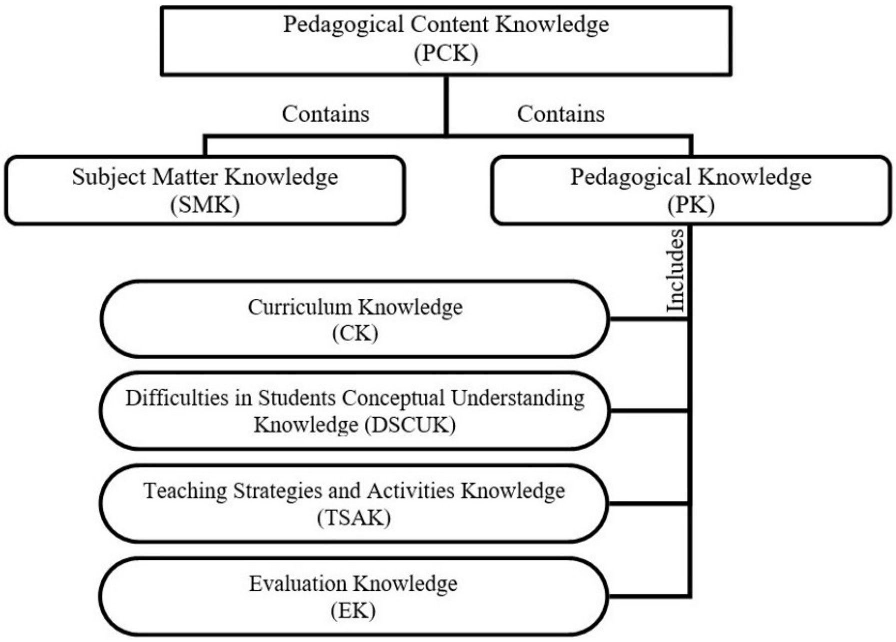


Figure 1. PCK Model (Kaya, 2009)

PCK is the knowledge of how to transfer knowledge of the subject in such a way that the information may be seen as meaningful to students. It also focuses on the teacher, who is the transferor of SMK. For this reason, it may not be possible to differentiate between SMK and PCK (Özden 2008). That is why the PCK of a teacher who does not have sufficient SMK is affected negatively by lacking of SMK (Even 1993). In other words, SMK plays an important role in the development of PCK and is also a prerequisite for PCK (van Driel, de Jong & Verloop 2002). Parker & Heywood (2000) tried to determine elementary teachers' PCK and SMK about buoyancy force, finding that whereas teachers should focus on the nature of force, they focused on the physical properties of force (for example we feel that the balloon is harder). It is important to determine teachers' SMK in order to prevent the formation of a chain of erroneous information that lasts for years without interference resulting from the transfer of knowledge that includes alternative concepts (Ültay & Çalık 2016; Ültay & Ültay 2014).

In this study, the SMK of prospective science teachers on overflow container was determined. Overflow container can be seen as a very limited topic to make a research but it is enough to make a real deep analysis. Because overflow container topic which is a part of buoyancy force requires making logical inferences and there are a lot of alternative conceptions about the topic, it is important to identify prospective science teachers' SMK. For example to relate the concepts of weight and floating-sinking (Havu-Nuutinen 2005; Moore & Harrison 2007), inability to differentiate density and weight concepts (Kang, Scharmann, Noh & Koh, 2005) are the results of erroneous physics education (Gürdal & Macaroğlu 1997). In Zhang, Chen, Sun & Reid's (2004) study which was based on the computer simulations, the most remarkable alternative conception on floating-sinking topic was that the magnitude of buoyancy force depended on the volume or shape of the floating object. Therefore, it is important to eliminate the alternative conceptions of prospective science teachers because prospective teachers will teach their own scientific information which possibly include alternative conceptions to the students in school (Ültay 2013; Ültay, Durukan & Ültay 2015). For this reason, to identify the SMK of prospective science teachers on overflow container may give clues about how to develop prospective science teachers' SMK and PCK and how to train them on the teaching context. This study tried to find answer to the question of "Does prospective science teachers' SMK of overflow container vary according to the levels of prospective science teachers?" For this reason, the purpose of the study was to determine prospective science teachers' SMK on overflow container according to the prospective science teachers' levels.

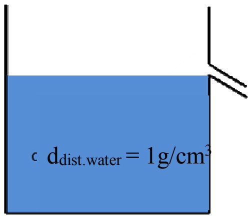
2. Method

The study was carried out in the form of a case study which makes possible to examine one aspect of the problem in a short time. The most important advantage of this method is the opportunity to focus on the special case of the problem (Creswell, Plano Clark, Gutmann and Hanson 2003; Wellington 2000). This case study examines SMK which is a part of PCK on overflow container. Likewise Merriam (1988) stated "Case study method is to test a program, a case, an individual, a process, an institute or a social group, a specific phenomenon", prospective science teachers are examined and evaluated in this study.

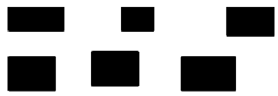
2.1 Data Collection Methods

Interviews were used to collect data about the prospective science teachers' SMK about "overflow container" and a case text was prepared to be presented to the participants during interviews and it is shown in Table 1.

Table 1. Case Text Presented in the Interview



6 solid objects with different characteristics.



Ali slowly puts 6 solid objects with different characteristics in overflow container filled with distilled water up to the overflow level. Then he makes some measurements and uses different solid objects in each time. ($d_{distilled\ water} = 1g/cm^3$).

1. **Measurement Result:** The volume of the overflowing liquid equals to the volume of the solid object dropped into the overflow container.
2. **Measurement Result:** The volume of the overflowing liquid is smaller than the volume of the solid object dropped into the overflow container.
3. **Measurement Result:** The weight of the overflowing liquid equals to the weight of the solid object dropped into the overflow container.
4. **Measurement Result:** The weight of the overflowing liquid is smaller than the weight of the solid object dropped into the overflow container.
5. **Measurement Result:** After the solid object was dropped into the overflow container, it did not become heavier.
6. **Measurement Result:** After the solid object was dropped into the overflow container, it became heavier.

Interviews consisted of seven main questions; the questions are as follow: "What is the working principle of an overflow container? Please explain" and "In the given case text (see Table 1) please describe the situation(s) occur in which the first measurement result Ali found." The rest of questions were repeated for the other measurement results. The interviews were recorded using a voice recorder, and each interview lasted approximately 15-20 minutes. The case text was given to the participants after the first question and response of the first question and then this case was repeated in accordance with the interview questions. The measurement results mentioned in the case text were given to the participants respectively and question by question and then the responses were expected. After the case text and the interview questions were prepared by the researcher, expert opinions were sought to determine the questions' reliability and validity. The expert in question was a male instructor who had completed his PhD in the UK and who had 23 years of experience in the "Integration of Information and Communication Technologies in physics education," "Material development in education," and "Research methodologies."

2.2 The Participants

This study was carried out during the spring term of the 2013-2014 academic year with prospective science teachers (sophomores) who had passed a general physics course in the Science Teaching Department of an Education Faculty of a university located in the Black Sea Region of Turkey. The upper group consisted of three prospective science teachers whose GPA scores were higher than 2.50 out of 4.00 while the lower group consisted of four prospective science teachers whose GPA scores were lower than 2.50 out of 4.00. Participants were included in the study with their own free-will.

2.3 Quality in the Study

In this study, volunteered participants were selected from sophomores. The researcher instructed General Physics Course I with the same participants three academic semesters ago and the participants knew the researcher before the intervention and at the same time they did not feel anxiety about grades. In this way, it was thought that the participants could have given more intimate answers and pro-long involvement was provided. Before the intervention, it was reminded that "data collected in the research will not have been regarded as grade", "data will have been used for only the research" and "data except some demographic information will not have been shared with the reader" to the participants. The purpose of this informing the participants was to provide comfortable and intimate responses.

In addition, credibility was enhanced by the way that interviews were carried out in the participants' home. Interviews which were lasted about 15-20 minutes and were performed face-to-face were recorded with a voice recorder. Case text that used in the interview was given to the participants after the first question was being asked and taken the response for the first question. The reason for this was to prevent to give a clue to the participants. Answers to the interview questions were asked in accord with the measurement results in the case text which were given respectively and question by question. The reason for this situation was to prevent that one answer may have affected the other one.

The data collected through interviews were coded four times (by determining critical answers) and placed into themes/categories in order to enhance credibility and dependability. The reliability and validity of these parts of the study were determined by expert opinion. One of these experts was a female chemistry educator with 8 years of experience whose professional expertise area was context-based learning. The other one of the experts was a female science educator with 10 years of experience and whose professional expertise area was constructivist learning theory. After the raw data obtained from the interviews were processed and necessary reductions were done, the processed data were controlled by each participant.

2.4 Ethics in the Study

Volunteered participants included in the study were selected from prospective science teachers that meet certain conditions (such as passing General physics course). The participants' consents were taken about sharing their responses in the interview with the reader. Also, the participants were informed about sharing some demographic information and their consents were taken. Before and after the interview, some special dialogues between the researcher and participant were not reflected in the study and it was remained between the two because of the principles of privacy and the confidentiality. In addition, participants were coded as P1, P2, P3, P4, P5, P6, P7 within the framework of research ethics, so name confidentiality was provided.

3. Findings

Scoring interviews depends on the researcher's aim and understanding model. It is possible to score the interviews about concepts, but it is stated that it may not be true to score interviews (interviews about events) (White & Gunstone 1992). Yin (1994) recommends placing the answers into categories based on the frequencies in order to compare interview data and to be able to identify consensus points or different thinking ways of participants. However, to reflect the individual's thoughts directly by quoting some of the sentences from the interview were believed to be very helpful. At the same time, Merriam (1988) argues that data which are directly related to the research subject need to be given in parentheses and should be transferred to the reader. By doing so, the readers are brought into direct confrontation with the data and they can decide what data mean by their interpretation (Miles & Huberman 1994). In addition, answers given in the interview can be presented in categories such as understanding, misunderstanding and missing (Coştu 2002).

In this study, the interview data were primarily transcribed verbatim and then analyzed. The transcriptions of the data were presented in Appendix 3. When the analyze methods mentioned above are considered, participants answers were categorized into "correct answer, partially correct answer, answer with alternative conception/wrong answer, irrelevant/missing answer" themes without scoring. After the first reduction, critical answers were shared with the readers. Themes/categories used in the interview and the content of the responses in these themes/categories are explained in below.

Correct Answer: Includes scientifically correct answers.

Partially Correct Answer: Includes one aspect of the scientifically correct answer but not include alternative conception or wrong information.

Answer with Alternative Conception/Wrong Answer: Includes answers with alternative conception or wrong explanations.

Irrelevant/Missing Answer: Includes irrelevant scientific or unscientific answers or situations in which students are not able to respond.

The upper group, who had a GPA greater than 2.50 out of 4.00, was coded as P1, P2, and P3. The lower group, who had a GPA of lower than 2.50 out of 4.00, was coded as P4, P5, P6, and P7. Participants' answers to the interview questions are shown in Table 2. "Floating," "sinking," and "hanging" concepts used in Table 2 are explained in Table 2 by the researcher in accordance with the participants' answers. The reason for this was to prevent possible data pollution in Table 2.

Table 2. Description of Cases Used by Participants in the Interview

Cases	Description of Cases
Floating	The case which the density of the solid object dropped into overflow container is smaller than the density of liquid.
Hanging	The case which the density of the solid object dropped into overflow container is equal to the density of liquid.
Sinking	The case which the density of the solid object dropped into overflow container is bigger than the density of liquid.

The correct answers used in the interviews are given in Table 3, respectively. Right answers of the interview questions asked to participants shown in Table 3 were controlled by a-24-year-experienced male physics teacher working at a high school of National Ministry of Education.

Table 3. The Correct Answers of the Interview Questions

Questions	Correct Answers
Question 1	Overflow container is a measurement tool that helps to find the object's weight, volume and density according to the position of the object in the container.
Question 2	This result is seen in the case of hanging and sinking because the volume of overflowing liquid is the same as the volume of the sinking part of the object.
Question 3	This result is seen in the case of floating because the volume of overflowing liquid is the same as the volume of the part of the object remained in the liquid.
Question 4	This result is seen in the case of hanging and floating because in these situations the weight of overflowing liquid equals to the buoyancy force and buoyancy force equals to the weight of the object.
Question 5	This result is seen in the case of sinking because when the liquid is overflowing as the magnitude of buoyancy force, the weight of the object is bigger than the buoyancy force, so it sank.
Question 6	This result is seen in the case of hanging and floating because the weight of overflowing liquid equals to the buoyancy force and buoyancy force equals to the weight of the object.
Question 7	This result is seen in the case of sinking because when the weight of overflowing liquid equals to the buoyancy force, the buoyancy force is smaller than the weight of the object. For this reason, sinking occurs.

The matrix shown in Table 4 reveals the participants' answers of interview questions seeking pedagogical content knowledge of overflow container. The matrix is filled up with the answers of interview questions. The answers are matched with the appropriate question and theme/category and shown with the participant's code.

Table 4. Data Obtained from the Interview

		Themes/Categories			
		Correct Answer	**Partially Correct Answer**	**Answer with Alternative Conception/Wrong Answer**	**Irrelevant/ Missing**
INTERVIEW QUESTIONS	**Question 1**	-	Overflow container is used for finding the densities and weights of the objects'. (P2) Overflow container is used for finding the volume of the objects in it. (P3; P7)	Overflow container is used to measure the volume of liquids and maybe it can be used in expansion subject. For example it can be used by heating overflow container and liquid whose expansion coefficient is different from the container. (P1) It is used to balance water or to measure the volume of water. (P4) Overflow container identifies overflowing water with the density which the object has in its real volume. (P5) It is used to overflow the small quantity of and it makes some measurement about water pressure. (P6)	-
	Question 2	This result is seen in the case of hanging and sinking because of that the liquid overflows as the volume of the sinking object. (P5)	This result is seen in the case of sinking, the liquid overflows as the volume of the object. (P1; P7) This result is seen in the case of hanging. (P4; P6)	If the density of the object in the overflow container is smaller than the density of the liquid, the liquid will not overflow, because of this the density of the object should be bigger than the density of the liquid (P2) This result is seen in the case of hanging and floating (P3)	-
	Question 3	This result is seen in the case of floating because the volume of the sinking object is small. (P1)	This result is seen in the case of floating (P4; P6)	This result is seen in the case of hanging. (P2) This result is seen in the case of sinking (P3) and the greater the density of the object, the more water is overflowing. (P5) This result is seen in the case of floating. Because if buoyancy force is bigger than	-

				the weight of the object, it floats, if they are equal, it floats in the middle, if it is smaller, it sinks. (P7)	
	Question 4	-	This result is seen in the case of hanging. (P1; P5; P6)	This result is seen in the case of sinking. (P2; P3; P4) By the formula of d=m/V, the density of the liquid and the density of the object should be the same. In this case the object floats, the half of the object is in the liquid, the half of the object is in the liquid. (P7)	-
	Question 5	This result is seen in the case of sinking. The volume of liquid overflowing equals to the volume of the object but because of the density difference the solid is heavier. (P7)	-	This result is seen in the case of hanging and sinking. (P3; P5) This result is seen in the case of hanging and floating. (P4) This result is seen in the case of floating (P6). Because the object places smaller in the liquid. (P1; P2)	-
	Question 6	-	This result is seen in the case of hanging and floating. (P2; P3) The liquid overflows as the weight of the object. This result is seen in the case of hanging. (P6; P7)	Because the volume of overflowing liquid and the weight of the object must be equal, the density of the object dropped into the container should be equal to the density of the liquid or should be bigger than the density of the liquid. The position of the object is hanging. (P1) The object dropped into the overflow container does not affect the weight of the container. This result is seen in the three conditions. (P4) This result is seen in the case of hanging. And the liquid does not overflow. (P5)	-
	Question 7	-	The weight of the object should be more than the weight of overflowing liquid. Because of this, this result is seen in the case of sinking. (P1; P3; P5)	This result is seen in the case of sinking. Because if the weight of the object is bigger, then it sinks. (P2) This result is seen in the case of floating. (P6) Overflow container will be heavier in the case of sinking. Because if the density of the object is smaller than the density of water, overflow container will be lighter. If they are equal, change is not seen. If the density of the object is more, it sinks and overflow container will be heavier. (P7)	The result will change according to the size of the object (P4)
Percentages of group and theme	**Upper**	4,76%	38,1%	57,14%	0%
	Lower	7,14%	39,29%	50%	3,57%

Note: Underlined answers show the answer with alternative conceptions.

In Table 4, all answers given by the seven participants for the seven main questions during the interview are presented. The most important and telling parts of answers obtained after the first reductions are shown in the matrix. When the answers in Table 4 are considered, it is seen that three participants gave correct answers for three questions. Upper group's 4.76% and lower group's 7.14% gave "correct answers." In the case text, P5 answered the first question correctly in that way: "Because the liquid overflows as the amount of sinking volume, this situation occurs when the density of the object equals to the density of liquid, it means when the object is hanging, and it occurs when the density of the object is bigger than the density of liquid, it means when the object is sinking in the liquid." In the case text, P1 answered the second question correctly in that way: "It occurs when the density of the object is smaller than the density of liquid in other words in floating situation because the sinking volume of the object is small."

The matrix used in Table 4 is considered, it is seen that upper group's 38,1% and lower group's 39,29% gave "partially correct answers". Some examples from partially correct answers are given here: P3 and P7 explained the question of "What is the working principle of an overflow container? Please explain." in this way: "Overflow container is used for finding the volume of the objects in it." The fifth question is answered by P2 and P3 in a similar way: "This result is seen in the case of hanging and floating." P6 and P7 said that "the liquid overflows as the weight of the object. If the density of the object and water is the same, I mean if the object is hanging position, this situation occurs." for the same question.

The matrix used in Table 4 is examined, it is seen that upper group's 57,14% and lower group's 50% gave "answer with alternative conception/wrong answer". Some examples from the participants' answers and alternative conceptions are given here: For the third question of the interview (In the case, please describe the situation(s) occur in which the second measurement result Ali found), P3 and P5 said that "if the density of the object in the overflow container is bigger than the density of the liquid, i.e. if the object is sinking, it occurs." which is counted as wrong answer. For the same question, P5 added that "because the greater the density of the object, the more water is overflowing." which is considered as an alternative conception. Similarly, for the fifth question "in the case, please describe the situation(s) occur in which the fourth measurement result Ali found", P6 said that "if the density of the object in the overflow container is smaller than the density of the liquid, i.e. if the object is floating, it occurs." which is considered as wrong. For the same question P1 and P2 gave answers including alternative conceptions such as "it occurs in floating situation because the object places less volume and so less liquid overflows." For the sixth question "in the case, please describe the situation(s) occur in which the fifth measurement result Ali found", all the participants' answers contain alternative conceptions. For instance, P1 said that "because the volume of overflowing liquid and the weight of the object must be equal, the density of the object dropped into the container should be equal to the density of the liquid or should be bigger than the density of the liquid. The position of the object is hanging." P4 said that "the object dropped into the overflow container does not affect the weight of the container. This result is seen in three conditions." and P5 said that "this result is seen in the case of hanging. And the liquid does not overflow." When the Table 4 is examined, alternative conceptions about the overflow container are summarized in the following:

- Overflow container is used to measure the objects' volumes (P1; P4),
- In the overflow container, if the density of the object is smaller than the density of the liquid, the liquid does not overflow (P2),
- The greater the density of the object in the overflow container, the more liquid overflows (P5),
- If the buoyancy force of the liquid in the overflow container is bigger than the weight of the object, the object floats, if equal, then the object hangs and if small, it sinks (P7),
- If the density of the object in the container is the same with the density of the liquid, the object floats (P7),
- If the object in the container is floating, i.e. if it covers a smaller volume in the liquid, the weight of overflowing liquid becomes smaller than the weight of the object dropped in the container (P1; P2),
- Volume and weight can be equal to each other (P1),
- If the density of the object in the container is bigger than the liquid, the object is hanging (P1),
- The object in the overflow container does not affect the weight of the container (P4),
- If the object is hanging in the container, no liquid overflows (P5),
- If the weight of the object in the container is big enough, the object sinks (P2),
- If the density of the object in the container is smaller than the liquid, the overflow container becomes lighter, if equal, no change in the weight of the container, if bigger; the overflow container becomes heavier (P7).

When the answers of the participants are considered, it is seen that only one answer fell into the irrelevant/missing category; this answer was given by a participant from the lower group to the last question. This answer constitutes 3.57% of the lower group participants. The last question given in the case text (Table 1) was answered by P4 as "The result will change according to the size of the object," an answer considered to be irrelevant.

4. Discussion and Results

In order to be a good science teacher, it is necessary to have the ability of bridging SMK and then PCK (Loughran, Berry & Mulhall 2006). When the answers of the upper and lower group are considered, it is seen that prospective science teachers have limited SMK about overflow container and they have some alternative conceptions and some wrong information (Özden 2008; Uşak 2005; 2009). In this case, if prospective science teachers do not fix this problem before graduation, prospective science teachers go into classroom as teachers; there will be a problematic issue for overflow container topic. Because they have insufficient SMK and already they have some alternative conceptions, their teaching will become confusing and meaningless for their students. A teacher has to know primarily SMK and then has to develop strategies or techniques for good transferring. But in this study, it is considerable that the number of the right answers in the interview is remarkably low. Also, it is noteworthy that the right answers in the interview do not vary upon the upper and lower group participants. The most important reason for this can be that the most of the participants have alternative conceptions about overflow container. Because alternative conceptions are resistant to change, a long time after they become harder and it is very difficult to overcome them (Garnett & Treagust 1992; Guzzetti, Williams, Skeels & Wu 1997; Taber 2001). Another reason can be that although ethics in the study were paid attention, the participants may have behaved timid and worried about not to respond in a right way.

It is revealed from the interview data that the participants who gave partially correct answers are from the upper and the lower groups have an equal rate. So this situation points out that there is no difference between the groups. Additionally, the high rate of partially correct answers indicates that the participants have incomplete information about overflow container. This case can be explained by that the subject is not learned in-depth by the participants and also their conceptual structure is not completed yet (Ültay 2012). Another reason for this can be the negative effect of the interview method on the participants. The interviewee and the interviewer should be in the same environment and in a face to face dialogue because it may have led the participants behave uncomfortable.

Another remarkable conclusion of the study is that prospective science teachers had a large number of alternative conceptions about overflow container. More than half of the respondents who gave answers with alternative conceptions can be seen as the biggest handicap that must be taken precautions. The participants who gave answer with alternative conceptions/wrong answer from the upper and the lower group have an equal rate. This situation implies that there is no difference between the upper and the lower group participants' understandings. The participants who gave correct and partially correct answers for some of the questions gave answers with alternative conceptions for the rest of the questions, so it means that they have some information containing alternative conceptions about overflow container. For instance, a participant who gave correct answer for the third question in the interview explained the fifth question with alternative conception. Another example, a participant who gave partially correct answer for the third question in the interview explained the sixth question with alternative conception. This situation can be explained by that alternative conceptions are parts of a thinking system and they interact with each other. Because of this, alternative conceptions that the participants have may lead to occurring new alternative conceptions (Ültay & Ültay 2014; Schmidt 1997; Stavy 1990).

Alternative conceptions appear in mind and are resistant to change and overcome (Guzzetti *et al.* 1997; Westbrook & Marek 1991). The reason for a large number of alternative conceptions may be that the instructor do not emphasize the alternative conceptions enough during the teaching process, and even the instructor or the book itself includes alternative conceptions. In addition, another reason may be that the instructor is not equipped with sufficient PCK and SMK (Özden 2008; Uşak 2005; Uşak 2009). According to Bahar, Ozel, Prokop & Usak (2008) the reason of prospective teachers' having alternative conceptions and inadequate SMK might be related with the teaching methods that are used in the classrooms as well as the nature of alternative conceptions itself.

When data obtained in this study are considered, it is seen that only one participant gave an irrelevant answer for the one question. This situation may have arisen from that all the participants have more or less information about the subject containing alternative conceptions or scientifically correct. All things considered, prospective science teachers have insufficient SMK in overflow container and most of them have alternative conceptions. In this way, when they will become teachers in the classrooms, they may transfer the scientifically inaccurate knowledge to the students. For a teacher, the most important element of teaching is having the SMK primarily, and then secondly developing strategies, techniques or good ways for transferring them to the students. Unless teachers have sufficient SMK in a topic, whatever they use perfect strategies or techniques, it is impossible to provide a successful teaching.

Based on this study's findings and conclusions, the following recommendations have been developed: (1) Instructors should be informed about alternative ways to conceive specific subjects, they can emphasize alternative conceptions during their teaching, and they should have planned their teaching appropriately. (2) Prospective teachers should be taught the importance of PCK, emphasizing the relation between PCK and SMK. (3) In university teaching experience courses (the courses aiming prospective teachers gain an experience in teaching such as school experience and teaching practice in education faculties), mentor teachers can be informed about PCK and SMK. In this way, professional contribution may be provided for prospective teachers regarding these issues.

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