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What do Pre-Service Physics Teachers Know and Think about Concept Mapping?

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In order to use concept maps in physics classes effectively, teachers' knowledge and ideas about concept mapping are as important as the physics knowledge used in mapping. For this reason, we aimed to examine pre-service physics teachers' knowledge on concept mapping, their ideas about the implementation of concept mapping in physics classes, the hidden elements influencing their ideas, and the relations between knowledge and ideas, qualitatively. The participants of this study were eight pre-service physics teachers enrolled in the physics education department at two state universities. The results of the interviews conducted with the participants and their artifacts revealed that although pre-service physics teachers had basic knowledge about concept mapping, they had some negative ideas about implementation in physics classes. Furthermore, language, limitation in assessment, limitation in expressions, and teacher's knowledge were identified as the sources of pre-service physics teachers' negative ideas.

Keywords: physics education, concept map, teacher education

INTRODUCTION

Knowledge is not obtained after a discovery, but it is created by individuals (Novak, Mintzes, & Wandersee, 2005, p.8). Novak (1995) described knowledge as an hierarchically organized set of concepts and relations among these concepts (propositions). By this description, he defined a concept map basically as "a way to represent the structure of knowledge" (Novak, 1995). As concept mapping represents knowledge visually, it also enhances the organization of knowledge in individuals' minds. The origin of concept mapping dates back to Ausubel's meaningful learning theory that implies that the connection among the concepts is the connection of prior knowledge and new information. In rote learning, individuals do not make a cognitive effort to relate previous and new concepts, however, in meaningful learning individuals integrate new knowledge to their cognitive structures, and knowledge is organized hierarchically (Novak, 2002; 2010a). By this way, the "richness of meaning" exponentially increased with valid propositions while connecting a concept with others (Novak, 2010b, p.45).

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State of the literature

- Concept maps are effective graphical tools representing knowledge since they connected the concepts meaningfully in the form of propositions (Canas et al., 2004; Novak, 1995; Novak & Gowin, 1984, p.15; Novak & Canas, 2008).
- Concept map(ping) can be used in science instruction by teachers for different aims in each period of instruction from preparation to assessment.
- Because of the importance of concept mapping in educational settings, science education literature is extensive about concept mapping research from 1990s up to now.

Contribution of this paper to the literature

- This study explores pre-service teachers' knowledge and ideas about concept mapping in physics teaching.
- The results of this study portray pre-service physics teachers' knowledge on concept mapping, their ideas about the implementation of concept mapping in physics classes, the hidden elements influencing their ideas, and the relations between knowledge and ideas qualitatively.
- These results might be helpful for teacher training programs of universities in improving pre-service teachers' knowledge of instructional methodologies and techniques, and in developing positive attitudes toward using alternative teaching and assessment methods.

Novak (1990a) explained they (with collaborators) used concept maps *first* to help students' meaningful learning of subject matter in science and mathematics at the college level. They are effective graphical tools representing knowledge since they connected the concepts meaningfully in the form of propositions (Canas et al., 2004; Novak, 1995; Novak & Gowin, 1984, p.15; Novak & Canas, 2008). Concept maps outline the major points of the topics in a systematical way and they make key ideas clear for both teachers and students (p.15), and give opportunities to exchange ideas and foster cooperation between teachers and students (Novak & Gowin, 1984, p.23). They can be used in science instruction by teachers for different aims in each period of instruction. For example:

(a) Before classroom instruction, concept mapping can be used in the instructional planning (Novak, 1990b; 1995);

(b) At the beginning of the instruction, it can be used as an advanced organizer in the exploration of students' prior knowledge (Willerman & MacHarg, 1991);

(c) During the instruction, it can be used in the exploration of students' misconceptions (Novak, 1990b), organizing students' learning (Canas et al., 2004; Novak, 1995), following conceptual change (Novak, 1990b), observing students' development, and encouraging science discussions in the class (Mintzes, Wandersee, & Novak, 1998, p.332);

(d) At the end of the instruction, concept mapping can be used for summary (Canas et al., 2004), and as an assessment tool (Kaptan, 1998; Kaya, 2003; Novak, 1990a).

Furthermore, concept mapping can be used in the planning of textbooks (Novak, 1990a; 2002), in curriculum planning and organization (Novak, 1990b; Novak & Gowin, 1984, p.23), and as a meta-cognitive strategy (Novak, 1990a; 1990b; 2002; Novak & Gowin, 1984, p.8). In addition, when it is used together with the other instructional methodologies, concept mapping provides superior achievement (Novak, 1990a).

There is no *unique* concept map about a subject. However, there are *good* concept maps that are constructed by considering the key points. Novak and Canas (2008) stated some key characteristics for constructing good concept maps:

(1) Focus question is required for clarifying the issue of a concept map.
(2) A hierarchy is considered for main concepts.
(3) Key concepts should be determined while drawing a concept map.
(4) Concepts should be in boxes or circled.
(5) The relationships between the concepts are in the form of propositions by connecting links.
(6) Links have directions from one box to another.
(7) Cross-links among the different domains are important.
(8) Some revisions might be done, but it never finishes.

Because of the importance of concept mapping in educational settings, science education literature is extensive about concept mapping research from 1990s up to now. Some research on concept mapping can be summarized as:

(a) Identifying students' conceptions/misconceptions by concept mapping and helping them achieve scientifically correct conceptual learning (Çıldır & Şen, 2006; Karamustafaoğlu, Ayas, & Coştu, 2002),

(b) Examining concept mapping as an instructional tool (Chiou, 2008; Kazancı, Atılboz, Doğan Bora, & Altın, 2003; Kılıç & Sağlam, 2004),

(c) Examining concept mapping as an assessment tool (Erdem, 2008; İngeç, 2008; 2009; Kaya, 2008; Novak, 1990a; Rice, Ryan, & Samson, 1998),

(d) Using concept mapping together with other instructional tools (Sungur, Tekkaya, & Geban, 2001; Uzuntiryaki & Geban, 2005),

(e) Developing quantitative evaluation methodologies for concept maps (Stuart, 1985),
(f) Developing qualitative evaluation methodologies for concept maps (Koca & Şen, 2004),
(g) Developing concept mapping tools (Canas et al., 2004), and,
*(h) Discussing reliability and validity issues for evaluating concept maps (*Eroğlu & Kelecioğlu, 2011; Rye & Rubba, 2002; Ruiz-Primo, Schultz, Li, & Shavelson, 1998).

New curricula of Turkish high school physics course (Ortaöğretim 10. Sınıf Fizik Dersi Öğretim Programı, 2008) stress the use of such type of methods and techniques (from grade 9th to 12th) both in the classroom to make students more physically and mentally active and in the assessments. For this reason, the *knowledge* and readiness of pre-service teachers in order to use these methodologies effectively are so important. However, knowledge does not guarantee the effective use of these elements. Teachers' adaptation and acceptance of them, and having positive ideas in order to implement in science classes are critical. Therefore, we need to examine pre-service teachers' *personal ideas* together with their knowledge. So the research aims of this study are to investigate:

- pre-service physics teachers' knowledge on concept mapping,
- their ideas about the implementation of concept mapping in physics classes,
- the hidden elements influencing their ideas, and
- the relations between knowledge and ideas.

METHODOLOGY

In order to have a detailed view, we preferred to conduct "a case study", which is known as an "in-depth study" (Gall, Gall, & Borg, 2007, p.447) of qualitative research.

Data Collection

Participants and the setting

We have two cases (two different participant groups) from the physics education departments of two state universities. Four students from each university (in total eight participants) formed the participants of this study. The participants were selected purposively from among the fifth-year physics education students, who have learned "instructional methodologies" in the related course(s). Additionally, in the selection of the participants, we considered participant's enthusiasm about being a physics teacher in the high schools in the following years. Final criterion in the selection of the participants was the pre-service physics teacher's success in pedagogical courses.

In the first case, there were three females and one male participant. The second group of students was also composed of three females and one male participant. The ages of participants in each group varied between 21-23 years. Both groups' participants were enrolled in the *old* physics education (before 2007) program where physics subject matter courses were given in the first 3.5 years, and then pedagogical courses were given in the final 1.5 years, in total a ten-semester program.

In both of the universities' physics education departments, an "instructional methodologies" course was compulsory for all pre-service teachers. Although the name of the course varied due to the universities, the content and the place of the course in the physics education program were the same. In the course, introduction of instructional methodologies and techniques were presented to teacher candidates in two following courses. The first course was given in the eighth semester, and the second one was given in the ninth semester of the physics teacher education program. Concept mapping was one of the techniques taught in the content of the course among the instructional methodologies and techniques such as cooperative learning, problem based learning, problem solving, project based learning etc. In the course, theoretical information about the different instructional methodologies and techniques were presented to pre-service physics teachers. In addition, they were allowed to practice the selected methodology by implementing it in the class. In other words, a teacher candidate teaches a physics topic using the learned instructional methodology or technique.

One difference between the courses taught in these universities was the language of the education. The first group participants experienced drawing concept maps in English; that means using English grammatical structure. The second group experienced it in their own language- Turkish.

Interviews

An almost one-hour interview was conducted with each participant. The interviews were in their native language, however, the participants were also allowed to use English if they needed. The two researchers of this study conducted the interviews, and they were video recorded.

The interviews had three main parts. In the first part, students were asked some questions about theoretical knowledge of concept maps. In the second part, they were requested to select a physics topic, which they know well, to show the characteristics explained in the first part of the interview. Therefore, sample concept maps were produced in the interviews. During this part, while pre-service teachers were drawing their map, they were also requested to think aloud. This way, we got a

chance both to examine students' implementation of theoretical knowledge into maps (transfer of knowledge) and to observe some hidden information that participants already had, such as not verbally explained theoretical information, their ideas, emotions, difficulties etc. In the third part, the questions were asked to identify their personal ideas about implementation of concept mapping in physics classes.

Data Analysis, validity, reliability, and ethical issues

First, the video recordings were transcribed. Then the map of each participant was matched with his/her interview transcript. The data was coded in participant based. In the data analysis, the steps in Miles and Huberman's (1984, pp.60-63) were followed: (1) naming the codes, (2) defining the codes, and (3) conducting double coding by two of the researchers. Then, the categories were obtained. In the second part, findings were examined and discussed in group based, by considering the two cases.

Credibility (internal validity) of the study was provided by peer debriefing and member checks. Two experts (a science and a mathematics educator) from out of the study examined the interview questions, and questions were revised after feedback. At the end of each interview, the participants were allowed to summarize their explanations for clarification.

Dependability (internal reliability) of the study was provided by examination of the data by independent analysis first. Then the researchers discussed the analyses in order to eliminate disagreements. Thus, almost full agreement, that means a coherent insight about each participant's explanations was obtained. In addition, the researchers interpreted the findings of the cases together by considering their own experiences about the contexts that the cases belong.

The ethical issues (Fraenkel & Wallen, 2000, p.43) were considered in the study. The participants were not placed under any physical or psychological harm. They were informed about the aim of the study, and their consent was obtained. They were allowed to leave the research if they did not want to continue the study. Finally, the confidentiality of the data was ensured.

RESULTS

Bloom's educational taxonomy for cognitive domain was considered in the evaluation of pre-service physics teachers' knowledge and ideas about concept map(ping). The questions examined three levels of students' theoretical knowledge such as knowledge, comprehension and application. However, the questions examining their ideas were in the upper levels since the pre-service teachers reflected their personal evaluations in these questions. The participants were coded from P1 to P4 for the first case; and from P5 to P8 for the second case. We presented the results in four sub-sections each corresponding to a research aim.

Knowledge about Concept Mapping

The answers of the first and second questions and the maps drawn for the fifth question were examined in this part. When participants were asked what a concept map(ping) was, all students gave satisfying explanations such as "P1: Concept mapping is a method of mapping the relations among the concepts", "P3: concept map is a visual representation of the relations among concepts by showing other related concepts", "P5: Concept mapping is a methodology that shows students could construct links among the concepts or not", "P8: Concept map is a cognitive schema of a student, so we can understand what a student know or does not know by examining his map" etc. Although the students in the second case were describing concept mapping from educational perspective by indicating students' knowledge, the participants in the first group described in a broad sense.

Next, the discussion of a good map showed that, all students explained "links (propositions), direction of arrows, hierarchy, key concepts and boxes" were needed to draw a good concept map that was described by Novak and Canas' (2008). In this part, we observed that the cases added different characteristics about concept map(ping). While the first case was indicating some characteristics such as "A concept map should be comprehensive, it should include pictures, it should not include too many words, it should gain attention, it should be easily read and not to make bored the reader", the second case added some characteristics such as "Propositions should be meaningful, there should be more cross links, it should include scientific words (not to include too many words), it should focus on a specific topic".

In the application of the theoretical knowledge while drawing a sample concept map, we observed that all pre-service physics teachers in the first group preferred to draw concept maps in English, and the second group preferred to draw in Turkish as they experienced in their respective courses. In Figure 1 and Figure 2 there are some sample maps that belong to a teacher candidate from each case, respectively.

When the sample maps in Figure 1 and Figure 2 were examined just structurally, Figure 1 shows a good example of a weak concept map. Although P2 preferred to draw a map in English as he experienced before, his map had a lack of hierarchy, key concepts, and cross links. In addition, propositions were missing or m eaningless and the structure of the map was linear. Like P2, the other participant (P3) presented such type of

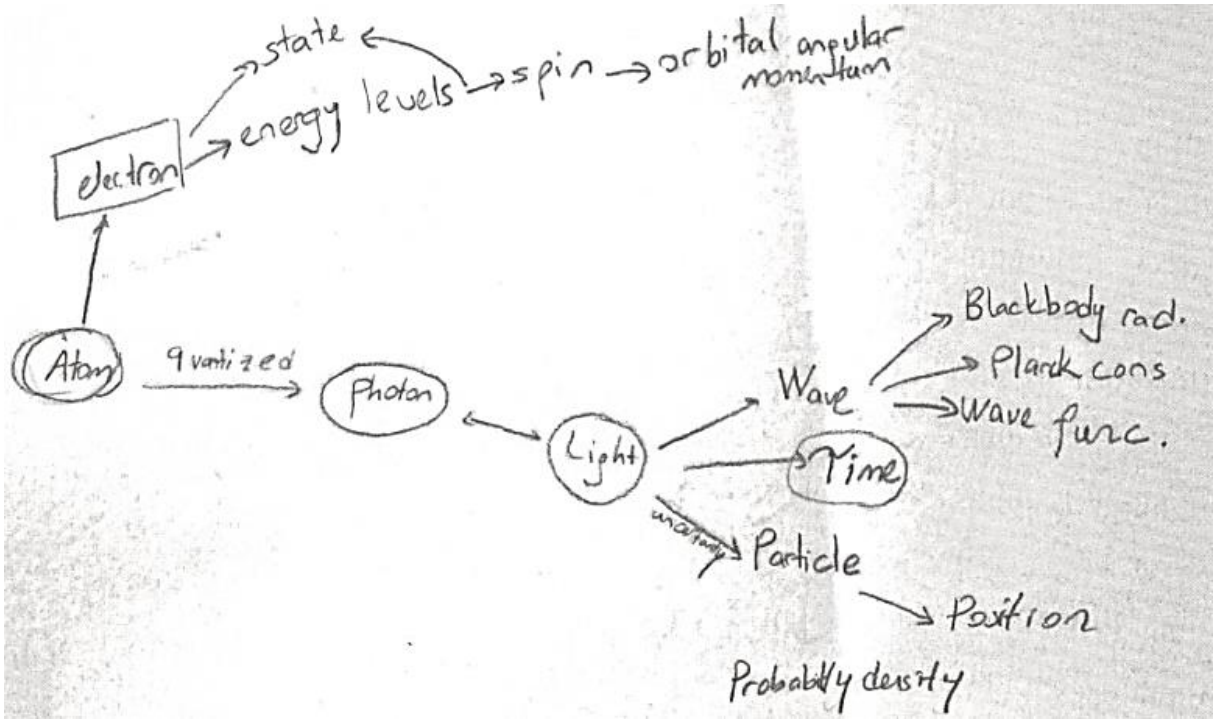

Figure 1. A sample concept map in English (P2).

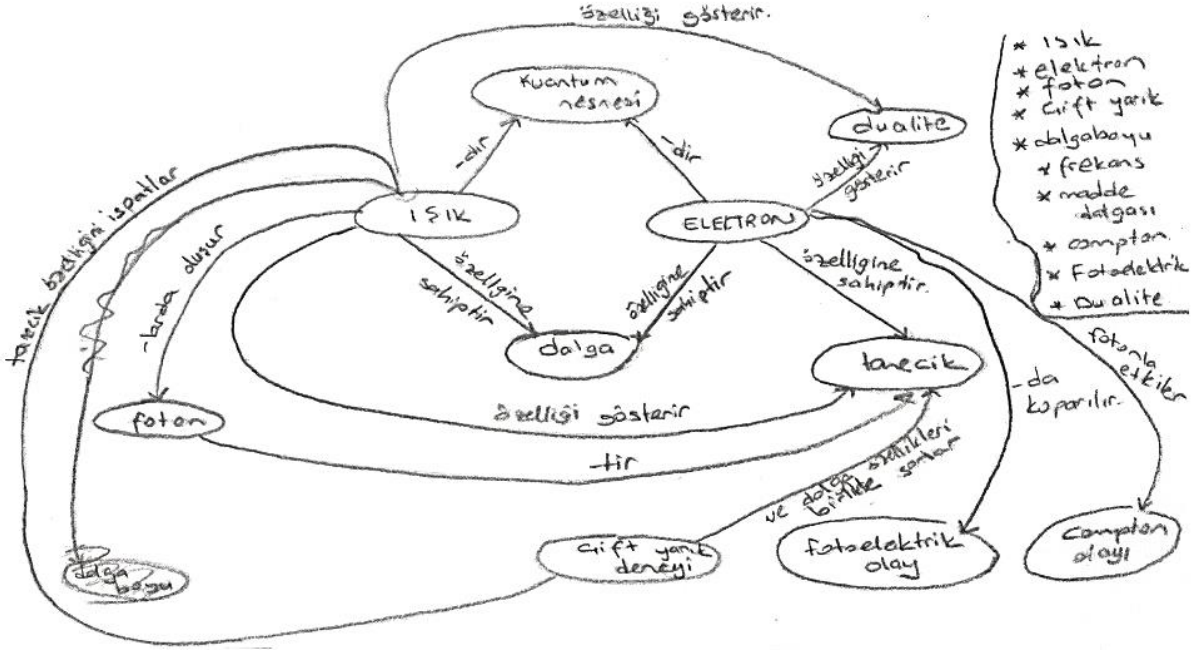

Figure 2. A sample concept map in Turkish (P5).

map with linear and unboxed concepts. The other two participants (P1 and P4) could draw a satisfying concept map. This result showed that although they knew concept mapping theoretically, they had difficulty in drawing good concept maps by considering the criteria of Novak and Canas (2008).

P5 in the second group presented more characteristics of a good concept map by hierarchy, key concepts, links and propositions. Before drawing the concept map, she determined her focus concepts and she got a pool by selecting key concepts around the focus concepts (light and electron). During mapping, she revised her pool and concept map. While drawing her map, as other participants in this group, she stated the difficulty of drawing concept maps in Turkish because of the mismatch with Turkish sentence structure. While drawing maps, pre-service teachers in this case could handle this difficulty by explaining aloud.

More specifically, they constructed sentences stating the box, then the other box, and finally link ([box][box]→). By this way, inverted sentences caused by links were prevented. In addition, when the maps were considered just as visual (excluding audio support by participant), the participants tried to remove meaningless propositions by writing long statements to link the boxes.

Ideas about Concept Mapping

For the second research question, pre-service physics teachers' ideas about implementation of concept mapping for different aims, the effectiveness of concept mapping, the possibilities of implementation for all physics topics and for all grades were examined. So the answers of the third, fourth and sixth- eighth questions in the interview protocol were examined together.

Pre-service teachers in both cases stated wide range use of concept map(ping) for different aims. These were:

(1) to identify students' prior knowledge,
(2) to identify students' misconceptions,
(3) to examine students' conceptual development during the class,
(4) to show relations among the concepts,
(5) to summarize the topic, for lesson planning, as advance organizer, for assessment.

It was good to see pre-service physics teachers had different use of concept mapping in their pedagogical knowledge repertoire. By shaping their theoretical knowledge by their experience, pre-service physics teachers stated just limited use of concept maps in their physics classes. In addition, they explained how they could make the use of concepts more effective. Table 1 presents their ideas about the use of concept map(ping) in their own physics classes.

As it is seen in Table 1, P3 explained that she preferred never to use concept map(ping) in her classes while teaching physics. She explains her reason as:

> P3: I think, concept mapping requires prior knowledge of students about taught concepts. If students do not have enough prior knowledge, that means, if a taught topic is unusual for students, it will be so abstract for them.

In contrast to P3, other teacher candidates stated that they could use concept mapping "to identify students' prior knowledge, to show relations among the concepts, to summarize the topic that I taught". Five of the students also explained they would use concept mapping for assessment of students.

As teacher candidates' aims about using concept mapping varied, their usage type also varied for different reasons. Among all participants, just P1 explained that she would draw a concept map by herself when she is a physics teacher. Others stated that they would draw a concept map together with students or/and request students to draw concept maps. Some of the participants explained more about how they used concept maps. For example, P6 wanted to use concept mapping both at the beginning of the classes and at the end of the classes. She stated variation due to the different usage aim:

> P6: At the beginning of the class, in order to identify what students know about the topic, I would not state the key concepts to students drawing a concept map. I would get idea about prior knowledge of students via concepts used in their concept maps. However, when I use concept mapping to assess students' learning, I would state the key concepts to students to draw a concept map, and I would examine how students construct relations among the concepts.

About the implementation of concept mapping for all physics topics, the pre-service teachers had two opposite ideas. The participants P3, P4, P5, and P7 thought that concept maps could be drawn for all physics concepts. These participants considered all physics concepts shared some common characteristics and they could be linked to each other. On the other hand, the rest of the participants, P1, P2, P6 and P8 stated concept mapping was impossible in advanced physics topics because of the complexity of the ideas, and the strange nature of the mathematical structures. In addition, these participants believe that the abstract concepts of quantum theory or relativity theory should not be made concrete by trying to draw concept maps.

Participants' ideas about the implementation of concept mapping for different grades were almost parallel with the ideas about implementation of concept mapping for all physics topics. Two of the participants, P1 and P8 strongly disagree towards the use of concept mapping at the university level. They thought that it is meaningless and funny to use concept mapping for students' who had abstract thinking ability since it limited students' ideas. For example, P8 explained his idea as follows:

> P8: It must be used in the elementary level. Because, students perceive *mapping* as a game, so they enjoy while doing and learning concept maps.

Two of the participants, P2 and P3, did not have explanations as negative as the previous group, however, they thought that the use of concept mapping was not effective in the upper levels. The rest of the participants were positive about the implementation regardless of grade level. They mainly focused that it would be more effective and enjoyable to use concept mapping in elementary level as the previous participants explained. P5 explained her idea as:

Table 1. Pre-service Physics Teachers' Ideas about the Use of Concept Mapping in Their Own Physics Classes.

	Pre-service physics teachers							
If I were a teacher,	*P1*	*P2*	*P3*	*P4*	*P5*	*P6*	*P7*	*P8*
I would use concept mapping								
to identify students' prior knowledge	-	-	-	-	+	+	+	-
to show relations among the concepts	+	+	-	+	-	+	-	-
to summarize the topic that I taught	+	-	-	-	-	-	-	-
for assessment	-	-	-	+	+	+	+	+
I would								
draw concept map together with students	-	-	-	+	+	+	-	+
request students to draw concept maps	-	+	-	-	+	+	+	+
draw concepts map and present students	+	-	-	-	-	-	-	-

For the approaches of teacher candidates (+) sign represents the positive approach and (-) sign represents the negative approach.

Table 2. Pre-service Physics Teachers' Knowledge and Ideas about Concept Mapping.

	Pre-service physics teachers							
Knowledge and Ideas	*P1*	*P2*	*P3*	*P4*	*P5*	*P6*	*P7*	*P8*
KNOWLEDGE (describing concept map(ping))	+	+	+	+	+	+	+	+
KNOWLEDGE (understanding its fundamentals)	+	+	+	+	+	+	+	+
KNOWLEDGE (drawing a good* concept map)	+	-	-	+	+	+	+	+
IDEA (about the implementation for different aims)	+	+	-	+	+	+	+	+
IDEA (about its effectiveness)	+	-	-	+	+	+	+	-
IDEA (about the use of it to teach all physics topics)	-	-	+	+	+	-	+	-
IDEA (about the use of it at all grades)	-	-	-	+	+	+	+	-

** by using the key elements defined by Novak and Canas (2008).*
For the knowledge of teacher candidates (+) sign represents the existence of knowledge and (-) sign represents the absence of knowledge.
For the ideas of teacher candidates (+) sign represents the positive idea and (-) sign represents the negative idea.

> P5: In elementary grades, students might not construct relations among the concepts. So by using concept mapping in the elementary school, we can improve students' abstract thinking ability.

Other participant (P7) stated the reasons of different aims to use concept mapping as:

> P7: In the elementary level, relations among the concepts can be explained by means of concept maps. However, in the secondary level, it is effective to use concept mapping at the beginning of the class in order to identify students' previous knowledge and to assess students learning.

The pre-service teachers, who thought concept mapping could be used in all grade levels, believed that the determiners were *complexity* and *quantity of used concepts*. That means, with good revisions by considering students' cognitive development, good concept maps could be drawn and used in physics classes in all grade levels.

Hidden Elements Influencing the Ideas about Concept Mapping

Although most of the participants thought that concept mapping was effective to teach physics, they believed that some elements decreased the effectiveness of the maps. We observed their enthusiasm about the use of concept mapping varied for these reasons. Among students' explanations, we identified some elements such as: *language*, *limitation in assessment*, *limitation in expressions*, and *teacher's knowledge*.

In both cases, pre-service physics teachers stated that they have difficulties in constructing concept maps in Turkish. In addition to their explanations, the participants in the second case presented these difficulties while drawing sample maps. Because of the grammatical structure of the Turkish language, propositions on the links cause inverted sentences. Other element shaping students' ideas was limitation in assessment. Although the teacher candidates stated that they could use concept mapping for assessment, some of them believed that concept mapping assessed basically knowledge and comprehension levels of cognitive domain in the Bloom taxonomy. So, they stated that they need extra methodologies to assess students' exact learning. Some of the pre-service physics teachers considered limitation in expressions. That means, concept mapping oversimplified the complex ideas. For this reason, they could not explain complex ideas and important interpretations by using concept mapping. The final element was teachers' knowledge. Most of the participants stated teacher's knowledge was so important to use this technique effectively. For example, P4 stressed that "Teachers must know how to

use concept mapping well. If they do not know well, it can be dangerous for students by causing misconceptions". P5 expressed that "Most of the concept maps in web and textbooks were wrong. Teachers should be able to select good concept maps among them". And, P6 expressed, "There must be a limit for the concepts. Teachers must determine the limits of the concept map and must implement it with controlling these concepts".

Interrelations between Knowledge and Ideas about Concept Mapping

Our final aim was to examine the relations between pre-service physics teachers' knowledge and ideas about concept map(ping). Table 2 was constructed to present the relations of students' knowledge and ideas about concept mapping.

By the examination of pre-service physics teachers' explanations and their sample concept maps, three structures related with knowledge and ideas were identified. The first structure was: The participants (P4, P5, P6 and P7) who knew concept mapping well and had mainly positive ideas about the implementation of concept map(ping) in physics classes. In contrast, the other participants (P1 and P8) presented mainly negative ideas although they were knowledgeable about the technique. In the last structure, we observed the pre-service teachers (P2 and P3), who had limited knowledge about the technique, reflected mainly negative ideas about the implementation and effectiveness, similar to the participants of the second structure. By considering the cases, these results showed that the participants of case one presented more negative ideas about the implementation and effectiveness of concept map(ping).

DISCUSSION AND CONCLUSION

Different from the previous studies about concept mapping with pre-service teachers (İngeç, 2008; 2009; Erdem, 2008; Eroğlu & Kelecioğlu, 2011; Karamustafaoğlu et al., 2002; Kaya, 2008; Kılıç & Sağlam, 2004), in this study we examined pre-service teachers' knowledge and ideas about concept map(ping) as critical elements of their pedagogical knowledge. The results of this study showed that pre-service physics teachers had basic knowledge, however, they need more information about how to implement the technique in physics classes. As teacher candidates, being knowledgeable about instructional methodologies is very important since teachers and the methods of teachers are the important factors that affect students learning. Their knowledge about instructional methodologies and techniques form their pedagogical knowledge, however, effective use of them while teaching the subject is based on the richness of the teachers' pedagogical content knowledge. At this point, it is extremely critical not to teach the instructional methodologies in their classes. They must teach subject matter by using these instructional methodologies and techniques. For this reason, examination of teacher candidates' knowledge about instructional methodologies is needed to get rid of misunderstandings about the use of different instructional methodologies and techniques.

Pre-service physics teachers in this study also evaluated the use of concept map(ping) in the physics classes and developed ideas about the implementation. All of the participants thought that concept map(ping) might be more effective and enjoyable in the elementary levels. This finding is similar with the finding of Şahin's (2001) study that pre-service science teachers stated concept maps should be used in elementary education. Half of the pre-service physics teachers had negative ideas about the use of concept map(ping) in upper levels. In contrast, Mahler, Hoz, Fischl, Tov-ly, and Lernau (1991) researched the use of mapping at university level in medical education explained that concept mapping could be used in learning, teaching and evaluation at university level. In addition, this negative idea of pre-service physics teachers' is almost parallel with that of the not constructing concept maps for all physics topics. However, Novak (1990a) explained that all domains of knowledge could be explained by concept maps i.e. basketball. By his experience, he stressed, "there is no domain of knowledge (or skills) for which concept maps cannot be used as a representational tool". At this point, teacher candidates' ideas about methodologies gain importance since they are the cues of how teacher candidates' approach, accept and use these methodologies in their classes. If we know the teachers' ideas about the methods, we may change their attitudes about these methodologies and techniques in a positive direction. As the previous studies (Chiou, 2008; Çıldır & Şen, 2006; İngeç, 2008; 2009; Kaptan, 1998; Karamustafaoğlu et al., 2002; Kaya, 2003; 2008; Kazancı et al., 2003; Kılıç & Sağlam, 2004; Mahler et al., 1991; Novak, 1990a; 1990b; 1995; 2002; 2010a; 2010b; Novak & Gowin, 1984; Novak et al., 2005; Willerman & MacHarg, 1991; Uzuntiryaki & Geban, 2005; Sungur et al., 2001) showed the effectiveness of concept mapping by different aims, the new curricula of Turkish high school physics course (i.e. Ortaöğretim 10. Sınıf Fizik Dersi Öğretim Programı, 2008) stress the use of such type of methodologies and techniques in physics classes from grade 9th to 12th. In this respect, the pre-service physics teachers' ideas about the concept maps come on the scene as a more important variable in this process, since they will become the pioneers in implementing the new curriculum.

We also observed that some hidden elements such as language, limitation in assessment, limitation in expressions, and teacher's knowledge influenced pre-service physics teachers' ideas about the implementation in physics classes negatively. The finding about language was comparable with the study of İngeç (2008) in which she identified pre-service physics teachers had some difficulty in constructing concept maps in Turkish.

In the examination of the relations between knowledge and ideas, we observed that four students were knowledgeable and had positive ideas about the implementation of concept mapping in physics classes. It is good to see knowledge enhanced positive ideas. However, in two of the students, we have observed that negative ideas existed in spite of being knowledgeable and the other two participants having negative ideas with insufficient knowledge. By removing the handicaps, which students' negative ideas are mainly based on, we believe that the participants' ideas may change from negative to positive. We have not observed any students, who are not knowledgeable but have positive ideas. This can be interpreted as important since as teacher educators we want teachers who would use methodologies if and only if they know the methods well. Without enough knowledge of a methodology implementing it might be harmful for students' learning.

As knowledge organization is important for learning in every domain, it is important in physics learning and solving physics problems (Reif, 1995; 1997). Reif (1995; 1997) stressed that incoherent and disconnected knowledge did not provide a good basis for problem solving in physics because being a good physicist requires having organized knowledge, which permits remembering and inferring the details (Reif, 1995). Having organized knowledge is also important for teachers' subject matter knowledge since they are the facilitators of meaningful learning of students (Mintzes et al., 1998, p.340) by providing connections with prior and new knowledge. For this reason, Novak (1990b) explained concept mapping was also useful in teacher education programs in two ways: (1) Pre-service teachers develop meaningful learning by emphasizing key concepts and relations among the concepts, required for their subject matter knowledge, and (2) They would be skillful to use such meta-cognitive tools. The concept maps might be useful for the preparation of the rich learning environments to teach physics concepts/issues, which are difficult to learn. In addition, some students might have difficulty in relating to physics concepts. By concept mapping, these relations might be shown and by drawing concept maps, problem solving might be enhanced (Novak, 1990a).

Concept maps play critical roles in "teaching, learning and curriculum" (Novak & Gowin, 1984, p.23). The results of this study, showing pre-service physics teachers' knowledge on concept mapping, their ideas about the implementation of concept mapping in physics classes, the hidden elements influencing their ideas, and the relations between knowledge and ideas qualitatively, might be helpful for teacher training programs of universities in order to improve pre-service teachers' knowledge of instructional methodologies and techniques, and to develop positive attitudes toward using alternative teaching and assessment methods.

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Appendix

Interview questions:

(1) What is concept map(ping)?

(2) What are the characteristics of a good concept map?

(3) For which aims is concept map(ping) to be used in the classes?

(4) If you were a physics teacher now, for which aims would you use concept map(ping) in your classes?

(5) Now, could you select a physics topic that you know well and draw a concept map?

(6) How should concept map(ping) be used for effective physics teaching?

(7) What do you think about the use of concept map(ping) for teaching every physics concept?

(8) In which grade level do you think that concept map(ping) is more effective?