PRE-SERVICE SCIENCE TEACHERS' METACOGNITION IN A SCIENCE LABORATORY COURSE WITH METACOGNITIVELY ORIENTED LEARNING ENVIRONMENT

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF SOCIAL SCIENCES
OF
MIDDLE EAST TECHNICAL UNIVERSITY

BY

BİRGÜL ÇAKIR

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF MASTER OF SCIENCE
IN THE DEPARTMENT OF
ELEMENTARY SCIENCE AND MATHEMATICS EDUCATION

SEPTEMBER 2011

Approval of the Graduate School of Social Sciences

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ABSTRACT

PRE-SERVICE SCIENCE TEACHERS' METACOGNITION IN A SCIENCE LABORATORY COURSE WITH METACOGNITIVELY ORIENTED LEARNING ENVIRONMENT

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September 2011, 214 Pages

Based on the importance place of metacognition in education, the current study aimed to investigate whether the embedded metacognitive prompts in the manual lead a change in PSTs' metacognitive knowledge and metacognitive skills. Throught 2009-2010 Fall semester, the data were collected from pre-service science teachers (PSTs) who enrolled in the Laboratory Applications in Science Education course. The course was offered as a must course in Elementary Science Education programme in one of the biggest universites in Ankara. The method selected for the study

was mix method. Both quantitative and qualitative data were collected and analyzed. Quantitative data was collected from 28 PSTs and qualitative data was collected from 7 PSTs who were the members of the researcher's group. In accordance with the purpose of the current study, descriptive statistics and independent samples t-test was conducted for quantitative data. In terms of qualitative part, the study was case study and interviews which were conducted before and after the course were analyzed to observe the change of PSTs' metacognition.

The result of the study revealed that before the course most of the PSTs did not report metacognitive skills. After the course it was observed that their metacognitive skills were developed. Among metacognitive skills, the most reported skill was monitoring skill after the course. It can be concluded from the study that metacognitive prompts embedded into the manual provided a metacognitively learning environment and a development in PSTs' metacognition.

Keywords: Metacognition, Prompts, Laboratory course

ÖZ

FEN LABORATUARI DERSI KAPSAMINDA FEN BİLGİSİ ÖĞRETMEN ADAYLARININ ÜSTBİLİŞ ODAKLI OGRENME ORTAMINDA ÜSTBİLİŞLERİNDE DEĞİŞİM

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Üst bilişin eğitimdeki önemi düşünüldüğünde, bu çalışmada laboratuar kitapçıklarına yerleştirilen üst biliş yönlendiricilerinin fen bilgisi öğretmen adaylarının üst bilişlerinde bir değişime neden olup olmadıkları incelenmiştir. Veriler 2009-2010 sonbahar döneminde fen bilgisinde laboratuar uygulamaları adlı derste fen bilgisi öğretmen adaylarından toplanmıştır. Bu ders Ankara'daki en büyük üniversitelerinden birinde ilköğretim fen bilgisi eğitimi programında yer alan zorunlu derslerden biridir. Çalışmada nitel ve nicel araştırma yöntemleri kullanılmıştır. Araştırmanın nicel boyutunda veriler 28 Fen bilgisi öğretmen adayından toplanmıştır. Nitel boyutu için de araştırmacının grubunda yer alan 7 Fen bilgisi öğretmen adayından veri toplanmıştır. Çalışmanın amacına uygun olarak, betimleyici istatistik testleri ve bağımlı örneklem t-test analizleri nitel verilerin analizinde kullanılmıştır. Nicel çalışma açısından çalışma nitel durum çalışmasıdır ve dersin uygulanmasından önce ve sonra yapılan

görüşmeler Fen bilgisi öğretmen adaylarının üst bilişlerinde ki değişimi gözlemlemek için analiz edilmiştir.

Çalışmanın sonucu göstermiştir ki, uygulanan dersten önce fen bilgisi öğretmen adaylarının pek çoğu üst biliş becerileri rapor etmemişlerdir. Derste yapılan uygulamadan sonra ise üst biliş becerilerinin geliştiği gözlemlenmiştir. Dersten sonra, üst biliş becerilerinin arasında en çok rapor edilen becerinin kendini izleme becerisi olduğu bulunmuştur. Yapılan çalışmadan, laboratuar kitapçığına yerleştirilen üst biliş yönlendiricilerinin üst biliş odaklı öğrenme ortamının oluşturulmasına yardımcı olduğu ve Fen bilgisi öğretmen adaylarının üst bilişlerini geliştirdiği sonucuna varılabilir.

Anahtar Kelimeler: Üst biliş, Yönlendiriciler, Laboratuar dersi

To all my family

ACKNOWLEDGMENT

I would like to thank my thesis advisor Prof. Dr. Hamide Ertepınar for her invaluable support, recommendation and endless motivation. Whenever I had to call her for guidance, she always helped me. Thank you sincerely.

I would like to thank my co-advisor Assoc. Prof. Dr. Özgül Yılmaz-Tüzün for her knowledgeable recommendation and time. There were times she studied with me during the holiday times. Thank you sincerely.

I would like to express gratitude to Prof. Dr. Hope J. Hartman for her invaluable support and help beyond the oceans. She answered my questions during the adaptation of manuals and analysis as well.

I would like to thank my mother Medine Çakır and father Ramazan Çakır for their endless love and their support to follow my dreams. I also thank my uncle Hasan Erdoğan for his valuable support and trust.

I would like to thank my dear friends Güliz Karaarslan, Zerrin Arslan, Neslihan Ayvaz, Erdinç İşbilir and Özgür Bal for their support with their wise and intimate friendship. I would like to thank Burcu Şenler for her help in the translations of the quotations, her suggestions and her endless smile which motivated me. Besides, thank you Aslıhan Osmanoğlu for her answers for my method questions. I would like to thank thank Demet Kırbulut as well who was my second coder during the analysis, her help was ivaluable and very useful for me.

I thank the members of my comittee for their willingness to serve on the comittee and for their valuable feedback.

I would also like to express my special thanks to the participants of the study. Especially the members whom I interviewed with, for their time and their help during the data collection. They were always helpful and sincere.

Finally, I thank TÜBİTAK for their scholarship during my master studies.

Thank you all very much indeed.

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PST: Pre-service Science Teacher

NOS: Nature of Science

CHAPTER 1

INTRODUCTION

"When you know a thing, to hold that you know it, and when you do not know a thing, to allow that you do not know it: That is knowledge."

Confucius

The quotation of Confucius refers to the importance of self awareness which is placed in metacognition. The self awareness of individuals about what they know and what they do not know are indicator of metacognition. This awareness is important in terms of education because it is thought that the meaningful learning and regulation of knowledge is related to this awareness.

1.1 Metacognition

Studies in metacognition started in the late of 1970s and the term was introduced by Flavell in 1979. Flavell (1979) defined metacognition as "knowledge and cognition about cognitive phenomena" (p.906). Another definitions widely accepted in the literature are "thinking about thinking" and "cognition about cognition" (Brown 1987; Garner & Alexander, 1989; Jacops & Paris, 1987). Jacops and Paris (1987) defined metacognition specifically for their study as the consciousness about the thinking. For example being aware of how characteristics of a passage influence understanding is metacognition. Definition of metacognition is a problem in the literature (Georghiades, 2004). One of the reasons is the placement of metacognition. Baker and Beall (2009) consider that metacognition is a super ordinate component for self-regulation. Whereas, Zimmerman (1995) accepts that self-regulation includes metacognition. Another controversial issue in metacognition is the characteristic of it. Some researchers consider that it includes motivation and affect, whilst some researchers state that metacognition should be thought in terms of knowledge types and regulation without affect domain

(Jacops & Paris, 1987). In this study, PSTs' metacognitive knowledge types and regulatory skills were considered without including motivation. Besides, in terms of the definition of metacognition, I accepted that being aware of the cognitive aspects of thinking which refers to metacognitive knowledge types and the awareness of regulation of cognition.

Another issue which makes the definition of metacognition vague is the components of metacognition. Flavell (1979) differentiate metacognitive knowledge from metacognitive experience. Later, Flavell, Miller and Miller (2002) made some change and they suggest a model for the components of metacognition. According to this model, the components are monitoring and self regulation and metacognitive knowledge. Furthermore, metacognitive knowledge includes person, strategy and task variables. According to Schraw (1998), two components are differentiated as metacognitive knowledge and regulation of cognition. Knowledge of cognition includes declarative knowledge, procedural knowledge, and conditional knowledge (Brown, 1987; Jacobs & Paris, 1987; Schraw & Moshman, 1995). Declarative knowledge focuses on what the learner knows about his /her cognition and what s/he knows about his/her strength and weak sides in learning. (Schraw & Moshman, 1995; Hartman, 2001; Schraw, 2001). For example a child may believe that the best way for him to learn something is to selecting main points and writing them with his/her own words. This example refers to declarative knowledge (Flavell, 1979). Procedural knowledge is the knowledge about how to do things. Knowing how to construct a concept map is an example. Finally, conditional knowledge refers to the selection of cognitive actions regarding to the situation and it also refers to the learner's rationale about the selection of strategy and when to use it. An example for conditional knowledge is when and where to use concept map. Another example is studying an exam according to the question style of teacher (Hartman, 2001; Schraw, 2001; Schraw & Moshman, 1995). For example, if a student's studying strategies are changing according to the test types, this refers to conditional knowledge.

This student studies multiple choice tests to recognize the true answer. However he/she studies open ended questions as a way to remember the context (Pintrich, 2002).

Regulation of cognition refers to the control of the learning and cognitive actions. Regulation of cognition is important since it helps students control the use of resources, time, and strategies (Schraw, 1998; Schraw 2001). Regulation of cognition consists of planning, monitoring, and evaluation. Planning concerns the allocation of sources, time, setting goals and the selection of the strategies (Schraw, 1998; Schraw & Moshman, 1995; Pintrich, 2002). Monitoring refers to tracking of awareness in learning. This tracking can be self-checking by asking questions yourself about reading, the material or the strategies (Pintrich, 1999; Pintrich, 2002). Finally, evaluation is revising the learning and setting future objectives. Besides, it includes re-evaluation of the objectives and the products or conclusions.

To sum up and prevent any misunderstanding, the use of concepts were summarized. Firstly, metacognition concept refers to metacognitive knowledge and skills. Metacognitive knowledge refers to declarative knowledge, procedural knowledge and conditional knowledge. Lastly, metacognitive skills refer to planning, monitoring and evaluation in this thesis study.

1.2. Metacognition and inquiry based laboratory course

An inquiry based laboratory is suggested since it enables learners to consider their experience, to plan their experiment and to make observations, collect data, make inferences, interpret the results. Students also had opportunity to communicate these results. Throughout this process they need to think on assumptions they made and to think critically so that they can find out the possible explanations. In addition, they have opportunity to discuss their results, the alternative explanations and assumptions which provide them to discover different thoughts of people. These features of inquiry based

laboratory enable learners a learning environment which support learners' metacognitive knowledge and metacognitive skills (Hofstein & Lunetta, 2004; Hofstein & Walberg, 1995; Kipnis & Hofstein, 2007). Hodson (1990) stated that laboratory courses are critically important for science learners to construct their knowledge by doing science. However, a laboratory course which does not guide learners to think on the purposes, methods and their exist knowledge is not properly designed (as cited in Kipnis & Hofstein 2007).

It was stated that inquiry based laboratory activities provides students opportunity to enhance metacognitive knowledge and metacognitive skills if it was well organized in terms of guiding discussions and provoking students' prior knowledge (Kipnis & Hofstein, 2007; Hofstein, Kipnis & Kind, 2008).

Thomas (2002) described the characteristics of metacognitive learning environment in eight dimensions based on the social constructivist view. These eight dimensions are (1) metacognitive demands, (2) teacher modeling and explanation, (3) student-student discourse, (4) student-teacher discourse, (5) student voice, (6) distributed control, (7) teacher encouragement and (8) support an emotional support.

I embedded metacognitive prompts to both provide metacognitive learning environment by considering Thomas (2002)'s definition and make PSTs think on their metacognitive knowledge and help them regulate their knowledge. Besides, I aimed to guide PSTs to make them aware of their existing knowledge with the help of these prompts. Their existing knowledge is important in terms of metacognitive knowledge and metacognitive skills. The reason for the selection of inquiry based laboratory course is that the nature of this course is appropriate for the investigation of PSTs' metacognition.

1.3. Metacognition in teacher education

Teachers' metacognition in education is accepted critically important in terms of being able to teach students how to learn (Duffy, Miller, Parsons & Meloth, 2009).

However, it is thought that much study is needed on metacognition in teacher education (Duffy, et al., 2009; Lin, Schwartz & Hatano, 2005). Lin et al. (2005) used "adaptive metacognition" term to refer the adaptation of teachers to various change in the classrooms. They stated that every classroom has their own climate and the needs of every student which are different from each other. Thus, a teacher should adapt herself/himself easily to these different environment and his/her solutions should change according to the different problems in classrooms. Teachers' metacognitive knowledge is important there. His/her knowledge for the strategies refer to declarative knowledge and changing the solutions in terms of instruction and class management refers to conditional knowledge (Lin et al, 2005; Lin, 2001; Duffy et al, 2009; Thomas, 2002). Therefore, teachers' metacognition is important for instruction and class management. According to Baylor (2002), increase in monitoring skill leaded teachers preparing constructivist based instruction plans and these teachers aimed meaningful learning for their students.

When the importance of metacognition in teachers thought, I aimed to investigate whether the embedded metacognitive prompts in the manual lead a change in PSTs' metacognitive knowledge and metacognitive skills.

1.4. Learning strategies

Learning strategies or learning techniques are the tools which include behaviors or thoughts while the learners engage in encoding process during the learning. These strategies are important for learner to select, analyze, reorganize knowledge and make connection with pre knowledge (Weinstein & Mayer, 1983).

Norman (1980) stated that educators expect students to learn a body of knowledge or solving a problem but they rarely teach how to learn, how to solve the problems and they do not tell the students about the art of memory. Weinstein and Mayer (1983) stated that "good teaching is teaching students how to learn, how to think and how to motivate themselves." To teach students how to learn and how to think, teachers should be aware

of and should have knowledge about the learning strategies and thinking types. Therefore, I wondered PSTs' learning strategies and whether metacognitive knowledge and skills are changing according to the learning strategies they have.

Weinstein and Mayer (1983) listed eight learning strategies. These strategies are shown in Table 1.1.

Table 1.1: Categories of Learning Strategies (Weinstein & Mayer, 1983)

1. Basic Rehearsal Strategies
2. Complex Rehearsal Strategies
3.Basic Elaboration Strategies
4. Complex Elaboration Strategies
5. Basic Organizational Strategies
6. Complex Organizational Strategies
7. Comprehension Monitoring Strategies
8. Affective and Motivational Strategies

Weinstein and Mayer (1983) defined these strategies as described below:

Basic rehearsal strategies are based on repeating names. Remembering the chronological order of historical events is an example for this category. Complex rehearsal strategies include copying a text to a paper. Underlying the main ideas in a text is an example. Basic elaboration strategies are matching a mental image to the learning task. Complex elaboration strategies include summarizing and paraphrasing or making connections between the new knowledge and the existing knowledge. The analogy between the circulation system and the distribution of electricity to a city is an example for this category. Basic organizational strategies refer to the organization of to be learned items. Complex organizational strategies refer to making diagrams to show the relationships. Comprehension monitoring strategies are self-checking to control the learning task. Affective and motivational strategies are the strategies to overcome the anxiety.

The PSTs' learning strategies, metacognitive skills and metacognitive knowledge they have are investigated for each case in pre-interview. Then the frequency of their

metacognitive knowledge and metacognitive skill are compared with regard to the frequency and type of their learning strategies.

1.5. Theoretical Framework

Schraw (1998)'s model was used as a theoretical framework for metacognition. The model is represented in the Figure 1. According to this model, metacognition has two components which are knowledge of cognition and regulation of cognition. The subcomponents of knowledge of cognition and regulation of cognition were explained above.

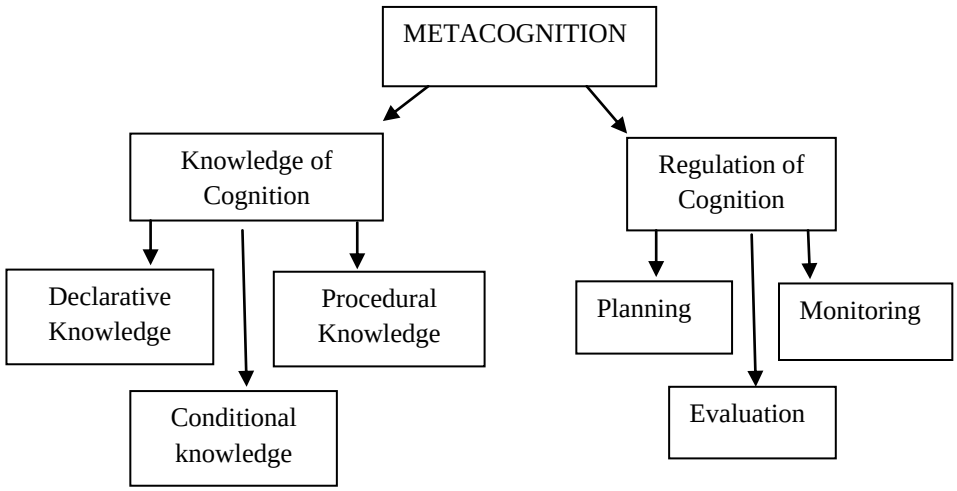

Figure 1.1: Schraw (1998) model for metacognition
Source: Kipnis & Hofstein (2007)

Shraw (1998) model was used for this study. The model focuses on both metacognitive knowledge and metacognitive skills. Kipnis & Hofstein (2007) used this theory in their study. Metacognitive knowledge was referred to declarative knowledge, procedural knowledge and conditional knowledge in Kipnis & Hofstein (2007) study. As similar to their study, metacognitive knowledge term was used in this study. According to Kipnis & Hofstein (2007) knowledge of cognition is a type of metacognitive

awareness and regulation of cognition components are accepted as regulatory skills. Therefore in this study, metacognitive skills refer to planning, monitoring and evaluation skills.

In order to discover the PSTs' learning strategies, Weinstein and Mayer (1986) learning categories which was explained above was used. According to Weinstein and Mayer (1986) learning strategies are critically important to understand students' learning process in terms of how they learn, how they encode and how they process the information. At this point the control of learning strategies requires metacognitive knowledge and skills. Therefore I also aimed to investigate the PSTs' learning strategies beside their metacognitive knowledge and metacognitive skills. The other aim of this study is to investigate the role of metacognitive prompts in an inquiry based laboratory course regarding to change of PSTs metacognitive knowledge and metacognitive skills.

1.6 Significance of the study

1. To enhance students' metacognitive knowledge and metacognitive skills, their teachers' metacognitive knowledge and metacognitive skills should be improved. The importance of teachers' metacognition is that metacognition supports meaningful learning and it contributes to academic achievement. However, metacognitive studies with teachers are scarce in the literature (Duffy et al, 2009). Therefore, I thought that I may contribute knowledge to the literature with the help of this study.
2. Use of prompts is a way to evoke metacognitive skills. In order to investigate PSTs' metacognitive knowledge and metacognitive skills, metacognitive prompts were embedded in the manual. I chose laboratory course because it is stated that laboratory activities support metacognitive skills (Duffy et al, 2009).
3. Another significant point is that it was aimed to create a metacognitive learning environment to evoke PSTs' metacognition. While creating this environment,

Thomas (2002)'s criteria for this environment was considered. Metacognitive learning environment is another issue that was not studied much (Duffy et al., 2009). Therefore, I investigated whether metacognitive prompts help to create a metacognitive learning environment

1.7 Research Questions:

1. What were the PSTs' perceptions about metacognition and metacognitively learning environment?
2. Was there a statistically significant change in PSTs' metacognition scores after the course?
3. Was there a statistically significant change in PSTs learning environment in terms of supporting the development of metacognition?
4. What kind of learning strategies and metacognitive knowledge and skills did PSTs have before the course?
5. How did the PSTs' metacognition change as a result of the course?
6. How did metacognitively embedded prompts help to create a metacognitively oriented learning environment in the science laboratory course?
7. What were the PSTs thoughts about the laboratory course with metacognitively embedded prompts?

CHAPTER 2

LITERATURE REVIEW

In this chapter, the background of the this study was explained in detail. Firstly studies in metacognition, the importance of it in learning environment and teacher education was presented. Finally, learning strategies were presented respectively.

2.1. METACOGNITION

2.1.1. Elements of metacognition

The studies in metacognition were started by Flavell in the late of 1970s. The first studies of Flavell were on metamemory. Later, he focused on metacognition and the term was firstly defined by him. The studies on metacognition include many disciplines such as psychology, education, special education, zoology (metacognition in animals) and neuroscience. Every discipline defines metacognition in terms of their own discipline usage. Therefore, there is an ambiguity in the definition of metacognition. Another controversial issue in metacognition is the characteristic of it. Some researchers accept that it includes motivation and affect. On the other hand, some researchers state that metacognition should be thought in terms of knowledge types and regulation without affect (Jacops & Paris, 1987).

Although the definition of metacognition is fuzzy, there are some definitions that are widely used in education. Flavell (1979) defined metacognition as the ability to planning, monitoring and evaluating one's own learning. Wilson (1998) defined metacognition as "Metacognition is the knowledge and awareness one has of their own thinking processes and strategies and the ability to evaluate and regulate one's own thinking processes" (pp.14). Besides, Flavell (1979) stated that metacognition manage

the cognitive activities and it help one select, monitor and evaluate the cognitive tasks. Furthermore, it leads one to interpret and make decisions on a certain task. Therefore, metacognition has a crucial role on problem solving, communication and critical thinking.

According to Flavell (1979), the components of metacognition are: (1) metacognitive knowledge, (2) metacognitive experiences, (3) goals (or tasks) and (4) actions or (strategies). Metacognitive knowledge refers to the beliefs and knowledge that one has for the cognition and learning. For example, a student's perception is that s/he is good at geometry. Another example is that you think that you learn science better when you do an experiment for the related topic. There are some factors that affect the metacognitive knowledge. These factors are person, task and strategy (Flavell, 1979). The person factor concerns the beliefs that one has for the cognition. Besides, the belief about the individual differences in cognition among people is also related to the person variable. For example a student's belief that s/he does not learn something easily while listening music. Task variable concerns the nature of the task that will be made a cognitive enterprise on it. For example remembering the structure of a story is easier than remembering it with the same words. The last variable is strategy that helps us learn and achieve the goals. For example a child believe that the best way to learn something is to selecting main points and wrote them with his/her own words. Flavell (1979) pointed out that metacognitive knowledge includes the interactions among these three variables. For example, you think that it is better choosing strategy X (differently from your friend and instead of strategy B) for the English course (instead of mathematics course). In this example one can see the three variables' interaction.

Metacognitive experience includes the cognitive or affective experiences that one is aware of. For example a student suddenly feels that s/he does not understand exactly what her/his friend told. According to Flavell (1979) metacognitive experience and metacognitive knowledge are different from each other in terms of the content and function. Another example for metacognitive experience is that while you are struggling

with a problem, you suddenly remember that you met a same problem before and handled with it. Another example for metacognitive experience is that you are writing your proposal and while reviewing the literature, you suddenly feel that you are far from your focus topic in your readings that time. Metacognitive experiences help one to revise the cognition, set new goals and change the old goals or strategies. Therefore, it can be concluded that metacognitive experiences have an important role on metacognitive knowledge in terms of revising and controlling it (Flavell, 1979). Flavell's model can be summarized like below.

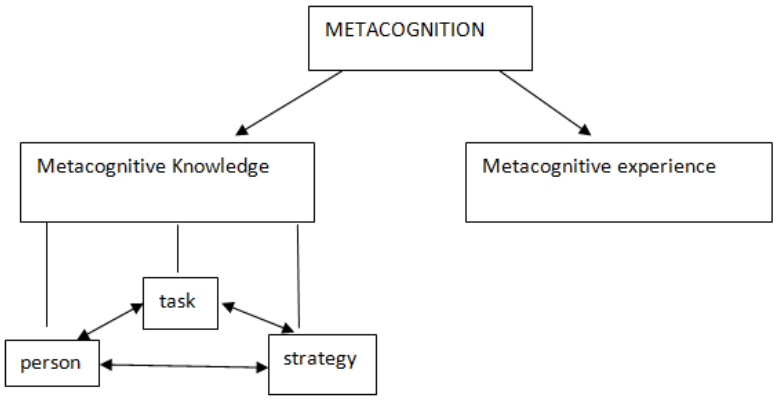

Figure 2.1: Flavell's model for metacognition
Source: Flavell (1979)

Although Flavell pointed out metacognitive experience as setting goals which refers to planning, changing the strategies, setting new goals which refer to monitoring, he did not differentiate regulation of cognition from knowledge of cognition. Later, knowledge of cognition and regulation of cognition were differentiated. Knowledge of cognition includes declarative knowledge, procedural knowledge and conditional knowledge (Brown, 1987; Jacobs & Paris, 1987; Schraw & Moshman, 1995). Declarative knowledge concerns the knowledge of cognition and learning that one has as a learner. Declarative knowledge includes facts and definitions and it is the answer to the "what"

question. For example, “what are learning strategies?” Procedural knowledge is the knowledge about how to do things. For instance, “How can I integrate inquiry method in my science lesson?” As understand from the name and the example, it mostly includes strategies and procedures (Schraw & Moshman, 1995; Hartman, 2001; Schraw, 2001). There are many strategies for learning. These strategies can be classified as rehearsal, elaboration and organizational (Weinstein & Mayer, 1986). These strategies will be explained in the next chapter. In addition to these learning strategies, there are also strategies for problem solving and with regard to thinking there are also some strategies like the validation of different situations, making decision according to the evidences, making inferences from a data and generalizing the decision to the appropriate sample (Pintrich, 2002). Finally, conditional knowledge refers to the selection of cognitive actions regarding to the situation. It is the answer to the “why” and “when” questions. Individuals with high degree of conditional knowledge know when and why to apply a strategy (Schraw & Moshman, 1995; Hartman, 2000; Schraw, 2001). As an example, most of the detectives are good at conditional knowledge. Although they know many strategies to solve an incident, they select the most appropriate one to solve it. It indicates that they know when and why to apply a strategy (Yıldız & Ergin, 2007). Furthermore, it shows that conditional knowledge also refers to the use of knowledge according to the social and cultural situations while selecting a strategy. For example, teachers’ exam strategies are different in many ways. Some prefers multiple choice tests, some prefers open ended questions and some prefers mix. If a student studies the exam and develops strategies according to the teachers’ exam ways, it shows that this student adapts his/her strategies according to the norms and the cultures (Pintrich, 2002).

Regulation of cognition refers to the control of the learning and cognitive actions. Regulation of cognition is important since it helps students control the use of resources, time and strategies (Schraw, 1998). Regulation of cognition consists of planning, monitoring and evaluation. Planning concerns the allocation of sources, time, setting goals and the selection of the strategies (as cited in Schraw & Moshman; Pintrich, 2002).

Monitoring refers to tracking of awareness in learning. This tracking can be self-checking by asking questions yourself about reading, the material or the strategies. Monitoring is important regarding checking the understanding (Pintrich, 1999; Pintrich, 2002). Finally, evaluation is revising the learning and setting future objectives. Besides, it includes re-evaluation of the objectives and the products or conclusions.

2.1.2. Development of metacognitive skills

There are some ways researchers use to promote metacognitive skills. Regulatory check lists are one of them. It is reported that these check lists even help young students regulate their knowledge and increase their metacognitive knowledge (Schraw, 1998). King (1991) used regulatory check lists for problem solving and he found that the checklists provide students questioning and these students gave more elaborative knowledge when compared with control group. These students were also more strategic while solving the problems.

Another tool is metacognitive prompts which evoke the metacognitive skills (Peters, 2007). Students do not force themselves very much to develop their metacognitive skills. Prompts act like a guidance for students to promote their metacognitive skills (Pintrich, 1999). According to Davis (2003) prompts are metacognitive in their nature and they help students plan and monitor their learning which enhance their metacognition. Furthermore, these prompts provide students be aware of their understanding and learning (Lin & Lehman, 1998).

Lin and Lehman (1999) designed a computer based laboratory course and used prompts to help pre-service teachers communicate their knowledge, results and discuss their explanations and reasons. They found that the group which was provided metacognitive prompts outperformed in problem solving.

Schwartz, Chase, Chin, Oppezzo, Kwong, Okita, Biswas, Roscoe, Joeng and Wagster (2009) made a study on interactive metacognition. They used metacognitive prompts via a teachable agent which was software. This agent asked questions (prompts) related to the topic and students teach this agent by creating concept maps and explaining the links among these concepts. Students monitor and evaluate the agent's learning. According to Schwartz et al, normally students neither check their learning nor monitor their progressing. However, when they use this software, students regulate their learning by monitoring and evaluating the agent's learning.

Tien, Rickey, and Stacy (1999) investigated the effect of prompts in conceptual understanding in the chemistry course and they found that the group which was encouraged by prompts outperformed (as cited in Davis, 2003).

2.1.3. Metacognition in teacher education

Studies on metacognition are on individual learning which is studied most. The other focus is on teaching which includes learning environment and teacher as a facilitator. It is known that teacher characteristics are one of the factor influencing student achievement. Therefore, to increase students' achievement, research on teacher education has become critically important. Besides, metacognitive teachers in education are essential to teach students how to learn (Duffy et al., 2009). However, studies on metacognition in teacher education are not very much (Duffy et al, 2009; Lin, Schawartz & Hatano, 2005). Lin et al used "adaptive metacognition" term to refer the adaptation of teachers to various change in the classrooms. They stated that every classroom has their own climate and the needs of every student are different from each other. Therefore a teacher should be metacognitively active to adapt herself/himself to these different environment and he/she should be adaptive metacognition to find solution for the different problems in classrooms in terms of planning, instructional selection, working with students and classroom management (Lin et al, 2005; Lin, 2001; Duffy et al, 2009;

Thomas, 2002). Teachers are facilitators who can provide metacognitively learning environment to students. Thomas 2002 defines metacognitively oriented environment in terms of students and teachers metacognitively participated in learning. He stated that "In metacognitively-oriented learning environments, students are asked by their teachers to be aware of and understand the reasons for the classroom activities. Teachers have expectations that, in addition to students thinking about the material to be learned, they will also think about (1) how they learn the material, (2) their difficulties in learning such subject material, and (3) how they could improve their learning of that material and so become better learners."

2.1.4. Metacognition in the inquiry based laboratory

Hofstein and Luneta (2004) described inquiry as "inquiry refers to more authentic ways in which learners can investigate the natural world, propose ideas, and explain and justify assertions based upon evidence and, in the process, sense the spirit of science." An inquiry based laboratory enables students to plan their experience, make observations, collect data, make inferences, interpret the results and communicate the results. Throughout the process they also think on assumptions they made and they need to think critically to find out the possible explanations. Besides, they have opportunity to discuss their results, the alternative explanations and assumptions. As a result, inquiry based laboratory environment is appropriate to provide learners metacognitively supported learning environment (Kipnis & Hofstein, 2007).

2.2. Learning Strategies

Weinstein, Husman and Dierking (2000) defined learning strategies as "any thoughts, behaviors, beliefs or emotions that facilitate the acquisition, understanding, or later transfer of new knowledge and skills" (p.727). Weinstein and Mayer (1986) suggested

eight categories for learning strategies. These strategies included rehearsal, elaboration, organizational, monitoring and affective strategies. Learning strategies are critically important for learners to be able to deal with new knowledge. These strategies help learners to organize knowledge and to encode knowledge to memory. Weinstein and Mayer defined each categories. According to them, rehearsal strategies are used for memorization. Repeating, remembering the order of something or copying a part of task is examples for this category. Rehearsal strategies may be insufficient for complex tasks. Elaboration strategies are more complex than rehearsal strategies that include mental image or constructing relationship among concepts. Organizational strategies refer to the organization of concepts regarding to a logical base. Construction of a taxonomy is an example for this strategy. According to the study of Moely, Olson, Hawles and Flavell (1969) students who were 10 or 11 years old could be able to use this strategy. However students under 10 years old could not use this strategy. Weinstein and Mayer (1986) used metacognition term while defining monitoring strategy. They stated that this strategy includes the learner's control ability for learning. Affective strategies mention to motivation, control of anxiety and time management.

CHAPTER 3

METHOD

3.1. Introduction

The main focus of this thesis was to investigate the change of PSTs' metacognitive knowledge and metacognitive skills via metacognitive prompts in the inquiry based laboratory course. The laboratory course was selected for this study since well designed laboratory courses give students opportunity to enhance their metacognition and enable students to control of their own learning and to monitor their study (Kipnis & Hofstein, 2007).

The laboratory course is a must course for elementary science education program and named as "Laboratory Applications in Science Education". The covered topics in the laboratory activities included biology, chemistry, and physics. Each week at least one laboratory activity is completed. Students are usually complete 10 laboratory activities during the course. To make the learning environment of this course appropriate for the metacognitive development, metacognitive prompts were added to the existing laboratory manuals.

3.2. Participants

The participants were PSTs enrolled in the Laboratory Applications in Science Education course. The course was offered as a must course in Elementary Science Education programme. All participants major were elementary science education except one PST. This participant's major was elementary mathematics education. There were 22 female and 6 male PSTs. The PSTs worked with their groups during laboratory work.

All PSTs have the same academic background that all participants have already taken biology, physics and chemistry lessons which were essential lessons to perform this laboratory course. It was assumed that all participants' previous knowledge was sufficient to perform the activities in the laboratory course.

3.3 Research Design

A mixed method was selected which includes both qualitative research design and quantitative research design (Yin, 2009). Qualitative research design was selected in order to explore the change in PSTs' metacognitive knowledge and skills throughout the laboratory course. For this purpose their pre-interview and post interview responses were compared, their laboratory manuals were examined and the researcher's field notes were used to understand the effect of metacognitive prompts on developing. In addition, Baker and Cerro (2000), and Garner (1987) stated that nature of metacognition required qualitative research method since participants may not understand the items in the questionnaires and participants may have tendency to forget the metacognitive processes they have (as cited in Yuruk 2005). Therefore, qualitative method was intended to understand the effect of metacognitive prompts in the change of PSTs' metacognition. In addition, every PST was considered as an analysis of unit and PSTs' metacognitive knowledge, skills and learning strategies were compared qualitatively.

3.3.1. Case study

Case study is appropriate for the studies which are looking for an in-depth understanding in the real life conditions in order to reflect the participants' perspective within defined boundaries for a phenomenon (Gall, Gall, & Borg, 2007). According to Merriam (1998), case study provides researcher make an in depth study within the natural conditions. This study is looking for in-depth description and change in PSTs' metacognition as a result of participating in the laboratory course with metacognitively embedded manuals.

One of the important points in the case studies is determining the boundaries for the study. According to Yin (2009) "*a study's questions, its propositions, unit(s) of analysis, the logic linking the data to the propositions and the criteria for interpreting the findings"* are important to define the boundaries. Firstly, the study's boundaries were identified according to these titles. The study's research questions were identified in the introduction chapter which were "how" questions. The second boundary is propositions. Propositions point out the attention that the reader should focus on. In this study, the aim is to take the readers' attention to the metacognitive skills, metacognitive knowledge and the learning strategies PSTs have and the change in their metacognitive knowledge and skills throughout the laboratory course. The third is unit of analysis which refers to what the case is. The unit of analysis is each PST in the researcher's groups. These PSTs were regarded as primary unit of analysis since the data were collected from each PST and then the results were compared among them.

A phenomenon has many aspects and the researcher focuses on the specific aspects related to the research questions (Gall, Gall, & Borg, 2007). In this study the phenomenon of the study was metacognition and specifically, the change of metacognitive knowledge and skills throughout the laboratory courses embedded with metacognitive prompts was investigated

Researchers choose case study specifically for one of the purposes below:

- To produce detailed descriptions of a phenomenon
- To develop possible explanations of it
- To evaluate the phenomenon (Gall, Gall & Borg, 2007).

The first purpose is named as "descriptive". The researchers aim to describe and conceptualize a phenomenon. The second purpose is named as explanatory. This type of case study aims to make an explanation and these explanations referred to patterns and these patterns classified under two titles. One is relational pattern and the other is causal

pattern. If a variable has a causal effect on the other variable, it is named as causal pattern. If this variable has not this causal effect, it is named as relational pattern. The last purpose is named as evaluation and it includes the researcher's judgments and the researcher made detailed description to both strengthen the evaluation and suggest something for the phenomenon being studied (Gall, Gall & Borg, 2007).

This thesis study was considered as descriptive and explanative. It was descriptive since the study described the learning strategies, metacognitive knowledge and metacognitive skills that PSTs had before and after taking the laboratory course. Meanwhile, it is explanative since it was thought that metacognitive prompts might have a causal relationship on developing metacognitive knowledge and skills in that metacognitive prompts might have potential to help PSTs develop their metacognitive knowledge and skills.

Yin (2009) identified four types of design which is used in case studies. He classified these designs under single case designs and multiple case designs. Single case design includes two types of design which are holistic (single unit of analysis) and embedded (multiple unit of analysis) case designs. The model of embedded multiple case design is showed in the Figure 3.1.

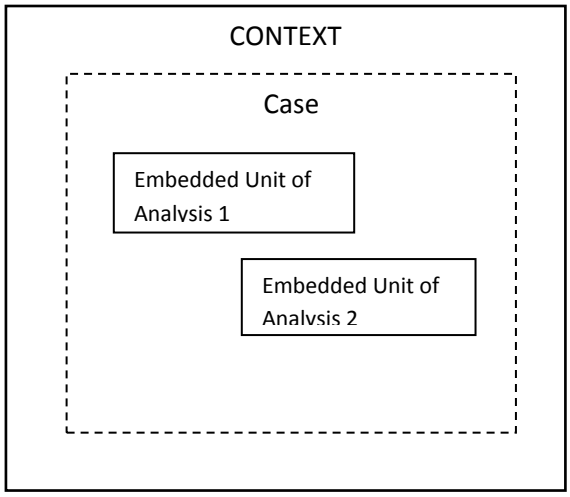

Figure 3.1: Single-case embedded (multiple units of analysis) design (Yin, 2009)
Source: Yin (2009)

Single case design refers to the only one case in a context, whereas multiple case designs refers to more than one case in a context. Besides, single case design includes only one context while multiple case design includes more than one context. The difference between single case and embedded multiple case design is that embedded multiple case design refers to more than one embedded unit of analysis.

In this study, single case embedded design was selected. The context was the laboratory application course with metacognitive prompts. The case was PSTs' metacognitive knowledge and skills. Lastly, the embedded unit of analysis was 7 PSTs whose assistants were the researcher. The figure of the research design was showed in the Figure 3.2.

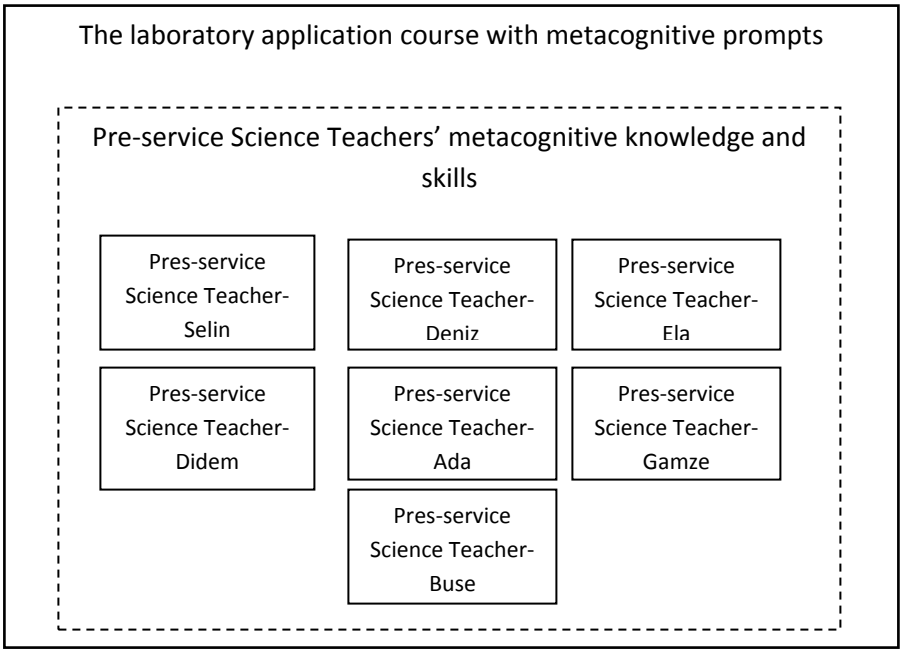

Figure 3.2: The research design of the study (seven units of analysis)

3.3.2 Context of the study

The context for the study was the Laboratory Applications in Science Education course. The course is a must course for the 3rd graders in elementary science education undergraduate programme. The main objective in this course is to develop PSTs' science process skills and understanding of nature of science and scientific inquiry by active engagement in laboratory activities. For the purpose of this study in addition to this objective, metacognitive prompts were added to the existing laboratory manual in order to develop PSTs metacognitive knowledge and skills. At the beginning of the course the PSTs were aware of the main objective but they were not told about the inclusion of metacognitive prompts into the manuals. At the end of the all lessons, firstly it was expected that the PSTs gain science process skills that they were able to integrate them into the elementary science laboratory courses. Secondly, they were aware of the importance of nature of science knowledge in science education and it was expected from them to integrate nature of science into their science teaching. Lastly, at the end of the lesson it was expected that the metacognitive prompts contribute an improvement to the PSTs' metacognitive knowledge and skills

The number of PSTs enrolled in this course was 28 and they were divided into two sections randomly. Each section included 14 PSTs. One section's of the course was on Mondays, the other one was on Fridays. There were four groups in each section and each group composed of three or four group members. Besides, each group had their own assistant who guided them while they were conducting their experiments throughout the course. The PSTs and the assistants were assigned to the groups randomly. The researcher had one group in each section. There were four members in her Monday group and three members in her Friday group. The role of group assistants was providing them the materials they require, helping them use time efficiently and guiding them by asking questions when they had problems. The assistants guided the PSTs according to the inquiry method. The course was performed according to the

laboratory manual. There were individual and group parts in the manual. The individual parts included the prompts for metacognitive knowledge and skills. The group parts also have metacognitive prompts that aimed to discuss the ideas, compare the models and ideas they have in the group and reach a decision for the activity.

Ten laboratory activities were conducted throughout the course. The first four laboratory activities did not contain metacognitive prompts. The manuals with metacognitive prompts began with the fifth laboratory manual. Totally six laboratory activities with metacognitive prompts were completed. The completion of each laboratory activity was taken approximately three hours. The typical process of laboratory courses is the introduction section taking approximately 15 minutes, the completion of the manual and experimentation taking approximately 140 minutes and finally the discussion part being completed in 25 minutes.

At the introduction of the each course, the researcher gave knowledge to the class about the topic, activity and the nature of science aspect for that day course. Then, each group worked with their assistants' and the manual's guide. At the end of the activity, a discussion was made in the class. The whole groups participated in the discussion. These discussions included the ideas for the activity, science process skills and nature of science aspect. Besides, the design of experiments and the models were compared to discuss on the differences and limitations of these designs. In the meantime, the groups' questions were answered as well.

3.3.3 The Laboratory Manuals

In order to develop the existing laboratory manuals, an expert committee was formed. One expert in this committee guided the researcher and the other two experts examined the manuals in terms of facial validity. In the light of the come tee's suggestion, the prompts were embedded to the manual.

PSTs in the course were not informed about the metacognitive object. The prompts were applied implicitly.

The objectives of metacognitive prompts in the manual were;

- Activating PSTs' prior knowledge to evoke their metacognitive knowledge and skills.
- Help PSTs focus on planning, monitoring and evaluating their thinking, knowledge and performance.
- Being aware of the other group members' ideas and approach to the tasks (there questions for individual and group answers).
- Getting multiple perspectives to the tasks by asking their individual ideas.
- To make PSTs rate their confidence relating to processes and products.
- To make PSTs explain the reasoning of their thinking.
- To make PSTs suggest and evaluate alternative interpretations, approaches or solutions
- To make PSTs transfer their daily life experience into the tasks

All the laboratory manuals were attached at Appendix A.

3.3.3.1. Laboratory 5: Black Box

Black box task had been adapted from Lederman and Abd-El-Khalick's (2002) study. This activity was elected since it provides students to develop their models based on their prior knowledge and it is an appropriate activity for an inquiry based laboratory activity.

Table 3.1 Metacognitive prompts used in the manual 5

Laboratory Manual 5: Black Box	
Prompts for metacognitive knowledge	• What can you infer based on your observations about the system inside the black box? Please write all plausible inferences you can make. • Explain the reasoning underlying your inference • Explain the basis of your confidence rating • What experiences gave you ideas to help you make sense of your model? • Where else in your life have you seen models like the one you designed? • Which observations and inferences make your own model strong when you compare it with your group's models? • Which observations and inferences make your own model weak when you compare it with your group's model? • How did you decide which model to design as a group • How did each member of your group contribute to the learning during this lab? • Did any member of your group give you ideas that you did not think of? • What do you conclude about the value of observation and inference in the scientific method? • Although you could not observe what is in the black box, you made inferences and constituted your hypothesis and created your model. Do you think that scientists make some inferences without observations and make explanations that are inferential in nature? Give some examples and support your answer.
Prompts for metacognitive skills	• Rate your confidence in your inferences on a 5 point scale from Not At All Confident to Very Confident. • Based on your observations and inferences suggest **your own model** that you think explain step by step how the phenomenon (or demo) works • How certain are you about the accuracy of the model that your group has drawn based on your group's inferences? • Draw a diagram, model or a concept map (it depends on your creativity) which shows what you have done and learned

There was a black box that the system in it was not seen. Then some water was put in the box and more water was taken from the box. It was asked to suggest a model which explains the system in the model. The PSTs firstly suggested their

Individual model and these individual models were not tested. Later, they discussed their individual models and suggest their group model and tested it. The prompts used in this manual were showed in Table 3.1.

3.3.3.2. Laboratory 6: Candle

The task had been adapted by Ozdem (2009) from the Pre-service Teacher Guide prepared by The Council of Higher Education in Turkey (2007). The purpose of this task was to support density concept via inquiry based activities. PSTs tried to reach evidence based conclusions and to test them.

In this task, three different liquids which were not known by the PSTs were given and it was asked them to observe the candles in these liquids. The aim of the task was to the reasons for floating and sinking of candles. Then the density of candle was asked to calculate. Metacognitive prompts that the researcher added in this manual were given in Table 3.2.

Table 3.2 Metacognitive prompts used in the manual 6

Laboratory Manual 6: Candle	
Prompts for metacognitive knowledge	• What are your ***inferences*** related to your observations? • Explain the basis of your confidence rating • what you did to solve this unexpected situation
Prompts for metacognitive skills	• In this step you are expected to design a method to test your inference according to the choice you made in the previous step. • Rate your confidence in your inferences on a 5 point scale from "Not At All Confident to Very Confident". • Rate the quality of your method on a 5 point scale from poor to

Table 3.2 continued

Prompts for metacognitive skills	• excellent • Did your method work as you had expected? If there were something unexpected • Design a method to calculate and/or measure the density of the candle you have selected. • Rate the quality of your method on a 5 point scale from poor to excellent • Draw a diagram, model or a concept map (it depends on your creativity) which shows what you have done and learned throughout the lesson

3.3.3.3 Laboratory 7: Theory & Law

This task was developed by Ozdem (2009). In this task, the PSTs were given Particle Theory of Matter and the Law of Conservation of Mass to study on. It was asked them to give evidences for the particle theory of matter. Firstly they give their evidences individually and suggest a design to test one of their evidences. Secondly, they discussed their evidences in their groups and select evidence and design an experiment and then test it as a group. Then, the activity for the law of conservation was performed. In this activity, it was asked them to design an experiment in a closed system which acts according to the law of conservation of mass Metacognitive prompts that the researcher added in this manual were given in Table 3.3.

Table 3.3 Metacognitive prompts used in the manual 7

Laboratory Manual 7: Theory & Law	
Prompts for metacognitive knowledge	• Explain your own thoughts on the role of theory in science with your own words. • Do you think that we really need theories? • Explain your thoughts on the role of law in science with your own word

Table 3.3 (continued)

	• Do you think that we really need laws? • What do you think about the validity and reliability of theories and laws? Explain the basis of your rating. • Is there a difference in your rating between theory and law? If any, why? • Write at least three evidences, which supports the claim that "Matter is made up of particles"? • What experiences gave you ideas to help you make sense of your experiment design? • Ask your group friends what they think on the evidence for particle theory. Is there a differently answers from yours? If any, do you accept as an evidence or not, why? • Write your ***observations/ data*** to the space provided below • Write your ***inferences*** related to your observations to the space provided below. • Is there a difference in rating? What are your group experiment's strong and weak sides when you compare it with your own model?
Prompts for metacognitive skills	• Rate your trust in theories on 5 point scale. • Rate your trust in laws on 5 point scale. • Design your own experiment to serve as an evidence to your claim • Decide on a claim as a group to serve as an evidence for the particle theory. Then design an experiment to to test the claim. • Rate your confidence in your individual method to test the claim • Rate your confidence in your group method to test the claim • Design an experiment to collect data to serve as an evidence to the law of conservation of mass • Draw a model that comes to your mind when law and theory is talked • Draw a diagram, model or a concept map (it depends on your creativity) which shows what you have done and learned throughout the lesson

3.3.3.4. Laboratory 8: Theory-Laden

This task had been adapted by Ozdem (2009) from the book *Teaching about Evolution and the Nature of Science* (National Academy of Sciences, 1998).

This task provides PSTs observe differences and similarities in the characteristics of human and apes DNA. Gorilla and chimpanzee were chosen as ape. The small section of gene for human hemoglobin protein sequence for human, gorilla and chimpanzee were given in the manual and it was asked them to hypothesize which state the relation among these organisms. They showed this relation by drawing morphological tree. Then they select either Darwin's theory or Lamark's theory to support their conclusion. A researcher who studies on evolution was invited to the class to lead the discussion part and at the end of the lesson the researcher explains why Darwin's theory is used instead of Lamark's theory. Metacognitive prompts that the researcher added in this manual were given in Table 3.4.

Table 3.4 Metacognitive prompts used in the manual 8

Laboratory 8: Theory- Laden	
Prompts for metacognitive knowledge	• Why cannot we call evolution as law? • How do scientists see evolutionary theory as scientific enterprise even though they do not see that is happening today or happened in the past? • Scientists give some different reasoning for the diversity of life such as mutation, migration, natural selection, etc. What could be the reason(s) for these different reasoning? Can you respond to this question in the light of NOS understanding, please provide examples to support your ideas?
Prompts for metacognitive skills	• Draw a model or a concept map which shows your understanding of evolution. • Draw a diagram, model or a concept map (it depends on your creativity) which shows what you have done and learned throughout the lesson.

3.3.3.5. Laboratory 9: Young Experiment

This task had been developed by Ozdem (2009). In this task, PSTs performed some experiments to observe the structure of light. PSTs constructed models, develop these models and make explanations via evidences that they get from experiments. They performed two experiments and one evidence was given. In each experiment and evidence they developed their models. In the first experiment they construct a model which shows light travel in straight line. Then, an evidence for photoelectric effect was given for the particle structure feature of light. Finally, they performed an experiment for the wave structure of light.

Metacognitive prompts that the researcher added in this manual were given in Table 3.5.

Table 3.5 Metacognitive prompts used in the manual 9

Laboratory 9: Young Experiment	
Prompts for metacognitive knowledge	• What can you infer based on your observations about the light? • Explain the reason(s) of your confidence rating. • Does this evidence support the light model you draw in the first part of the experiment? Explain why it supports or why it does not support your model. • What can you infer about the light based on your observations in three experiments? • If your model has been changed, explain why they change? Can you respond to this question in the light of NOS understanding?
Prompts for metacognitive skills	• Rate your confidence in your inferences on a 5 point scale from "Not At All Confident" to "Very Confident". • Based on your observation(s) and inferences suggest a model to explain the structure of light. • Draw a group model which explains the structure of light. • Rate your group model on a 5 point scale from Not At All Confident to Very Confident. • If the evidence does not support your model, modify your group

Table 3.5 (continued)

	• model to include this piece of evidence given above. • If every group member agrees on this evidence does not support your group model, suggest a group model which includes this piece of evidence. • Draw a diagram, model or a concept map (it depends on your creativity) which shows the process have done and learned throughout the lesson

3.3.3.6. Laboratory 10: Creativity in Science

This laboratory is related to understanding the creativity in science via observations and inferences. An instrument which was unknown by PSTs were given. It was asked them to drive theories about the function of this instrument and perform an experiment to show the functionality.

Metacognitive prompts used in this manual were showed in Table 3.6.

Table 3.6 Metacognitive prompts used in the manual 10

Laboratory 10: Creativity in Science	
Prompts for metacognitive knowledge	• What can you infer based on your observations about the function of the instrument? • Explain the reason(s) of your confidence rating. • As a group, what can you infer based on your observations about the function of the instrument? • When do scientists need to use creativity? • How is creativity important in science? Can you give an example? • How do you need creativity in your daily life?
Prompts for metacognitive skills	• Rate your confidence in your inferences on a 5 point scale from "Not At All Confident" to "Very Confident". • Rate your confidence in your group inferences on a 5 point scale from "Not At All Confident" to "Very Confident".

Table 3.6 (continued)

	• Based on your observation and inferences suggest an experiment to show the functionality of the instrument you have. • Draw a diagram, model or a concept map (it depends on your creativity) which shows the process you have done and learned throughout the lesson

3.4. Data Collection

3.4.1. Data Collection Procedure

Quantitative data were taken from 28 PSTs. Qualitative data were taken from 7 PSTs who are in the researcher's groups.

The PSTs were randomly divided into two sections. First section's lesson was on Monday, the second's was on Friday. Each section includes four groups and each group consisted of three or four group members. Besides, each group has its own assistant. As a researcher I had one group in each section and the qualitative data were taken from these two groups since as a researcher I had opportunity to observe and take notes for these groups. Totally there were 7 PSTs that I have collected qualitative results from. These 7 PSTs major were science education and their academic backgrounds were similar.

All the participants attended the course voluntarily and their permission was taken for the audio and video records. To make students familiar with the audio and video records, data collection was started from the 4th laboratory manual which did not contain any metacognitive prompts.

3.4.2. Quantitative Data Collection

Self Awareness scale developed by O'Neil and Abedi (1996) was used as a metacognitive inventory. Metacognition was measured via four subscales which were *planning, monitoring, cognitive strategy,* and *awareness. Planning* subscale measures that one must have a goal and a plan to achieve the goal. *Self-monitoring* subscale measures that one needs a self-checking mechanism to monitor achievement. *Cognitive strategy* subscale measures that one must have a cognitive or affective strategy to monitor either domain independent or domain dependent intellectual activity. *Awareness* subscale measures that the process is conscious to the individual." There were five items in each subscale. Totally there were twenty questions in the scale. Alpha reliability was reported as .91 (N=99) for the undergraduate students. The alpha reliability values for awareness was .79, for cognitive strategy was .81, for planning was .83; and finally for self-checking was .75.

To investigate whether a metacognitively learning environment was provided, Metacognitive orientation scale (MOLES-S) developed by Thomas (2002) was used. The scale has seven subscales. The alpha reliability for metacognitive demands subscale was.72, for Student-student discourse was .84, for Student-teacher discourse was .84, for Student voice was .80 for Distributed control was .87 for Teacher encouragement and support: was .86 and finally for emotional support was .86.

Thomas (2002) defined these subscales as: "*Metacognitive demands*: Students are asked to be aware of how they learn and how they can improve their science learning. *Student-student discourse*: Students discuss their science learning processes with each other. *Student- teacher discourse*: Students discuss their science learning processes with their teacher. *Student voice:* Students feel it is legitimate to question the teacher's pedagogical plans and methods. *Distributed control*: Students collaborate with the teacher to plan their learning as they develop as autonomous learners. *Teacher*

encouragement and support: Students are encouraged by teacher to improve their science learning processes. *Emotional support:* Students are cared for emotionally in relation to their science learning."

Both questionnaires were conducted in English. The education language is English in this university. Therefore, PSTs could undertstand and response each items.

3.4.3. Qualitative Data Collection

3.4.3.1. Laboratory manuals

All participants in the course completed the same manuals. However, the researcher's groups' manuals were analyzed for this study. In meantime, laboratory manuals were used as a metacognitive tool since they include the metacognitive prompts.

3.4.3.2. Interviews

The PSTs in the researcher's group were interviewed before and after completing all manuals with metacognitive prompts. Two of the interview questions ("How confident do you feel about learning science?" and "Do you need to think scientifically in everyday life") were taken from Peters (2007)'s dissertation. The rest of the interview questions were developed by the researcher. There were both common and different questions in pre and post interviews. There were some different questions in the post interview since the questions about the PSTs' thoughts about the manuals were asked. Due to the restricted time, the pilot study for the interview questions had not been made. The questions were examined by the researcher's advisor and co-advisor to understand how well questions covered the research's aim. According to her advisor's and co-advisor's comment some change were made. The interview protocol was attached in Appendix B and Appendix C.

3.4.3.3. Field notes

According to Yin (2009) taking notes is a useful tool to observe the participants and these field notes may be used in triangulation of the results. In this study, field notes were not used in triangulation because the researcher took the notes when extraordinary things were observed. For example, a PST specially thanked me to support their learning by asking questions instead of telling the answer directly. Another example is that while the PSTs handling with the questions in the manual, one of them said her friends with laughing as a joke that "I think I do not have metacognition to answer the questions". I noted these extraordinary situations.

3.5. Data Analysis

3.5.1. Quantitative Data

Paired samples t-test was performed to understand whether there were significant differences in pre and post tests for subscale of *self awareness scale* and *metacognitive orientation scale (MOLES-S).*

3.5.2. Qualitative Data

Before analyzing the data all interviews were transcribed into word document by the researcher and each transcription were controlled to check for missing words.

To analyze the qualitative data, two models for metacognition were selected. The first model is based on Shraw (1998)'s model of metacognition. Second model is Flavell, Miller, and Miller (2002)'s metacognition model (Kipnis & Hofstein, 2007). These two models were presented in the introduction chapter. According to these two models, pre and post interviews were analyzed in order to categorizing each PSTs' metacognitive knowledge and skills. Then the results of pre and post interviews were

compared to understand whether there was a change in their metacognitive knowledge and skills. Kipnis and Hofstein (2007) also used these two models to analyze the students' metacognitive skills. While analyzing the results, the study of Kipnis and Hofstein (2007) guided me. Kipnis and Hofstein (2007) analyzed their data regarding to the model of Shraw (1998) and Flavell, Miller, and Miller (2002). Besides, in terms of metacognitive strategies, the codes emerged from the study of Kipnis and Hofstein (2007) were used.

To analyze the PSTs' learning strategies, Weinstein and Mayer (1983)'s categories for learning strategies were used. These strategies were also presented in the introduction chapter. First of all, the codes for learning strategies were revealed from pre-interview and then the codes were categorized according to the learning categories of Weinstein and Mayer (1983). Then, the PSTs metacognitive knowledge and strategies were compared regarding to their learning strategies.

Case study research provides researcher intensive and holistic description about the case (Creswell, 2007; Merriam, 2009). Yin (2009) identified four strategies and five techniques to analyze the case study. These four strategies are; *relying on theoretical propositions, developing a case description, using both qualitative and quantitative data* and *examining rival explanations*. One can use any of these strategies or can use a combination of them. Yin (2009) explained the use of each strategy. According to him, *relying on theoretical propositions* strategy is mostly used strategy. The theory which shapes the study helps the researcher lead the case study. The propositions in the theory shape the data and lead researcher to focus on certain part of data and ignore the rest of data. In this way, the researcher can reduce data to analyze. While analyzing our data, Schraw (1998)'s model, Flavell et.al.'s model for metacognition and Weinstein and Mayer (1983) categories for learning strategies help me focus on the relevant data to analyze. *Developing a case description* strategy is less preferable when compared with the first strategy. This strategy enables the researcher to organize the data by developing

a descriptive framework. In our study, in light of the frameworks, a descriptive analysis with frequencies was provided in a table for each case. Lastly, *both qualitative and quantitative data* analysis strategies were also used in this current study. Using quantitative data also provided evidences for triangulation.

According to Miles and Huberman (1994), to analyze the qualitative data, first step is the reduction of data rationally. Developing summary sheet, emerging codes and categories and writing memos are example for reducing the data. In our study, the researcher formed summary sheet for each PSTs to both reduce the data and focus the relevant data in order to answer the research questions. These summary sheets were presented in the table format. In these tables, there were four columns at the bottom. One was for questions, the second was for the PST's answer in pre-interview, and the third one was for the PST's answer in post interview and the last column was for the researcher's notes. Table 3.7 showed an example for the summary sheet.

Table 3.7: Summary sheet example

Questions	PST's answer in Pre-Interview	PST's answer in Post-Interview	Notes

In order to show the PSTs' metacognitive knowledge, metacognitive skills and learning types, the sentences which referring them, were showed as a table.

3.6. Trustworthiness

Creswell and Miller (2000) listed eight strategies which were selected from 29 strategies suggested by Whittemore, Chase and Mandle (2001). According to Creswell (2007) among these strategies, at least two strategies should be selected to satisfy the validation of the findings. *Prolonged engagement* is listed as a one of the strategies to satisfy the validity issue. It provides the researcher to be familiar with the participants and the participants can accustom to the researcher. Thus, it becomes easier to collect data for researcher. In this study, the first 4 laboratory manuals did not include any prompts. During this time, the researcher and the participants had a chance to know and understand each other. The next 6 laboratory manuals included the prompts to enhance the PSTs' metacognitive knowledge and skills. Meanwhile, the researcher observed the participants during these ten weeks.

Triangulation is another strategy in this list. According to Denzin (1978), there were four types of triangulation: (1) *data triangulation* (2) *investigator triangulation* (3) *theory triangulation* and (4) *methodological triangulation*. *Investigator triangulation* refers to corroborating the results from different investigators. *Methodological triangulation* means that the results from different methods verify each other (as cited in Patton, 2002). In this study, both methodological and investigator triangulation were used. In terms of methodological triangulation, qualitative and quantitative methods were used to compare the results. The researcher transcribed pre and post interviews and analyzed the results. Then, investigator triangulation used to confirm the classification of codes and categories in the study. Investigator triangulation method is also known as peer review (Lilcoln & Guba, 1985). In this study, a peer who is making research on metacognition and a well known researcher was asked to code the data. Then the results were compared and the inconsistent results were discussed. Later, the agreement was provided. Moreover, the results were reviewed by the researcher's advisor and co-advisor. Consequently, this study satisfied the validity issue.

3.7. Researcher's Role

Merriam (2009) identified researcher's role as a primary instrument for data, data collection and interpretations. My role in this study was collecting data, analyzing and interpreting them and facilitating groups' activities. I observed my groups' members while they were conducting their experiments. There were some concerns I had before conducting the research. One of them was that I might not take sincere answers. The other was that due to the restricted time PSTs might not reflect all of the thoughts they had during the activities. To overcome these concerns, I followed some strategies. Firstly, I began to collect data in the 6th week of the course. This provided time for me to establish friendly relationships with my participants. At the beginning of the semester some of them hesitated to tell what they were thinking and feeling for the lesson. However, they considered me as a friend in time and they began to write sincere answers in the manuals and to discuss the concepts during the lessons. I also told them that during the course I was going to collect data for my thesis. One day one of my participants told me that "I felt comfortable during the course and did not hesitate to tell and write my thought because I knew that you care my thoughts and me." This close relationship also enabled PSTs to speak sincerely during the interviews.

In terms of researcher's bias, as a researcher, I searched the articles, thesis and dissertations and have a view about metacognition from these literature searches. As a researcher before conducting this study, I had believed that metacognitive prompts are useful tool to enhance students' metacognition. Therefore, besides the metacognitive prompts, my attitude towards PSTs may encourage them to make more effort on the manuals.

3.8. Ethical Issues

The permissions for the questionnaires were taken from the authors and these scales were added Appendix D.

To protect participants from harm and to ensure their privacy, ethical issue is important in qualitative studies (Miles & Huberman, 1994). Permission from Ethical Committee at Middle East Technical University (METU) was taken and all PSTs in the course were asked for their voluntarily participation in the study. All PSTs were willing to participate in the study. Besides, they were informed that their names were not revealed instead pseudonyms were used in the analysis. The prompts in the manual and the questions in the interviews were not any harmful effect on the subjects. The PSTs in the researcher's group were informed that this study was a master thesis study and their voluntary is important for the manuals and interviews. They all were willingly participating into the study.

3.9. Assumptions of the Study

The assumptions which were thought were listed below.

- All ethical issues were satisfied. To ensure this, permission from the ethical committee was taken.
- The PSTs answered the questions in the interviews sincerely. To make them feel comfortable while answering the questions, pre-interview data were collected 2nd week of the course. In this time they were informed that their privacy is protected and I tried to sustain a trustful environment in the class.
- The audio recorder did not affect participants' answers in the interviews. To make participants accustom to the recorder, it was put in the table in the courses. In time, they said they got used to the recorder and they did not aware of the existence of it.
- Prompts in the manual contributed PSTs' metacognitive development positively. To ensure this, professional help was taken. A professor in the metacognition controlled the manual and gave advises to develop the manual in a metacognitive way.

3.10. Limitations of the Study

The limitations of this study were listed below.

- Participants' number taking the course was 28 which is not a sufficient number for the quantitative data analysis. The number of participants is not sufficient to satisfy the external validity Issue. The results from this case study may be generalized to the subjects who have the same features with these participants. Researchers using case study research give all the circumstances, features of the participants, materials and the reader may generalize the results to the parallel situations or subjects (Yin, 2009; Merriam, 2009).
- To reduce the researcher's biases, the interpretations should have been checked with the participants. To reduce this limitation, the interpretations were controlled by the peer review, the researcher's advisor and co-advisor.
- The instruments were conducted in English. They were not translated in Turkish. The education language is in English in this university. Therefore, PSTs did not have difficulty in understanding the items. However, further research can be conducted to consider this issue.

CHAPTER 4

RESULTS

The results in this chapter are represented in two sections. First section presents the quantitative results and the second section presents the qualitative results.

4.1. Quantitative Results

4. 1.1. Research Question 1: What are the PSTs' perceptions about metacognition and metacognitively learning environment?

As it was stated in method chapter, PSTs' metacognition was assessed by using self-awareness scale and the learning environment was assessed by using MOLES-S scale.

Descriptive results for PSTs pre and post tests for their metacognition and metacognitively learning environment results were given below. Paired samples t test was used to compare pre and post test results of self awareness and MOLES-S subscales for each scale.

Table 4.1: Descriptive Statistics for self awareness subscales

	M	SD	Min	Max	Skewness	Kurtosis
Pre-awareness	2.95	.46	1.80	3.80	-.337	.166
Post-awareness	3.20	.34	2.60	4.00	.328	-.042
Pre- cognitive strategy	3.01	.40	2.20	3.80	-.150	-.511
Post-cognitive strategy	3.21	.34	2.60	3.80	.346	-1.01
Pre-planning	3.16	.37	2.40	3.80	-.145	-.833
Post-planning	3.33	.33	2.60	3.80	-.211	-.821
Pre-self checking	3.06	.38	2.20	3.80	-.314	.018
Post-self checking	3.17	.37	2.60	4.00	.415	-.349

The result of descriptive analysis revealed that the lowest score in the pre test was awareness subscale of self- awareness. It means that the PSTs were not aware of their own thinking, their techniques and strategies. Even though the lowest score was awareness subscale, the maximum increase was measured in this subscale. It may be concluded that the metacognitive prompts may cause increase in the participants' self awareness. However, the highest score in pre test and post test was planning which suggested PSTs had a goal to achieve something and they had ability to plan their time and resource in order to be successful.

In general, an increase in the scores of subscale of self awareness scale was observed after the course. It may be suggested that metacognitive prompts in the laboratory course may contribute to this increase.

Table 4.2: Descriptive Statistics for Metacognitive orientation scale

	M	SD	Min	Max	Skewness	Kurtosis
Pre-Metacognitive Demands	3.62	.71	2.40	5.00	.363	-.51
Post-Metacognitive Demands	4.24	.56	2.40	5.00	-1.37	2.80
Pre-Student-student discourse	3.45	.95	1.80	5.00	.003	-1.04
Post-Student-student discourse	3.92	.89	1.40	5.00	-1.07	1.03
Pre-Student-teacher discourse	3.40	.98	1.00	5.00	-.40	.45
Post-Student-teacher discourse	3.04	.40	2.20	3.60	-.28	-.70
Pre-Student voice	3.94	.70	2.20	5.00	-.76	.15
Post-Student voice	4.37	.76	1.40	5.00	-2.25	7.48
Pre-Distributed control	2.78	.82	1.20	4.20	-.11	-.56
Post-Distributed control	3.08	.81	1.40	4.20	-.33	-1.13
Pre-Teacher encouragement and support	3.91	.78	2.00	5.00	-.60	.133
Post-Teacher encouragement and support	4.28	.81	1.25	5.00	-1.93	5.85
Pre-Emotional support	4.18	.68	2.20	5.00	-.90	.99
Post-Emotional support	4.19	1.01	1.25	5.00	-1.56	2.18

Descriptive results of MOLES-S showed a general increase for each subscale of MOLES-S except for student-teacher discourse subscale. In conclusion, the lowest score in the post test was observed in the student teacher discourse subscale. On the other hand; the highest score was observed for student voice subscale of MOLES-S.

4.1.2. Research Question2. Was there a statistically significant change in PSTs' metacognition scores after the course?

Paired Samples t-Test

Before conducting paired samples t-test, the assumptions for each scales were checked. The assumptions suggested for the checking are: (1) level of measurement, (2) random sampling, (3) independence of observations, and (4) normality

1. Level of measurement assumption: In order to conduct parametric tests, dependent variable is required to be measured at interval or ratio level by using continuous scale (Tabachnick & Fidell, 2001). In the present study, dependent variables are measured by continuous scale. Therefore; this assumption was satisfied.

2. Random sampling: Parametric approaches assume that the sample is selected randomly from the population. This present study used convenience sampling, hence this assumption was violated.

3. Independence of observation: Each of the measurement need to be independent that individuals must not be influenced from each other. Data were collected by the researcher and she tried to prevent the interaction among PSTs while they were providing their responses to the items of the scales.

4. Normality

The difference between the pre and post scores must be distributed normally. Kolmogorov-Smirnov values were checked for this assumption and the results were given in Table 4.3. According to the results. Except for self checking subscale all subscales satisfy this assumption. Skewness and curtosis values were also acceptable for the normality assumption.

Table 4.3: Test of normality for self awareness sub scales

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
awareness	,148	28	,118	,960	28	,342
cognitive strategy	,128	28	,200	,946	28	,155
planning	,152	28	,095	,965	28	,458
self checking	,199	28	,006	,878	28	,004

Table 4.4: Test of normality for MOLES-S sub scales

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
metacognitive demands	,156	28	,077	,960	28	,353
student student discourse	,129	28	,200*	,965	28	,453
student teacher discourse	,110	28	,200*	,958	28	,316
student voice	,200	28	,006	,956	28	,282
distributed control	,113	28	,200*	,980	28	,852
teacher encouragement	,150	28	,106	,962	28	,385
emotional support	,114	28	,200*	,964	28	,433

After checking the assumptions, paired samples t-test was conducted to compare the self awareness and MOLES-S subscale scores and the results were given in Table 4.5.

Table 4.5: Paired samples t-test values for self awareness and MOLES-S sub scales

	t	p	Eta squared
Self Awareness			
awareness	2.365	.025*	.17
cognitive strategy	2.234	.034*	.16
planning	2.073	.048*	.14
self checking	1.34	.191	.06
MOLES-S			
Metacognitive demands	3.84	.001*	.35
Student student discourse	2.24	.033*	.16
Student teacher discourse	1.89	.69	.12
Student voice	2.144	.041*	.15
Distributed contribution	1.83	.168	.11
Teacher encouragement	1.83	.78	.11
Emotional support	.185	.855	.012

*****significant at .05 level

Results showed that regarding to self awareness scale there was a statistically significant difference in PSTs' awareness, cognitive strategy, and planning. The estimated eta squared for awareness subscale was .17 indicating a medium effect size. The estimated eta squared for cognitive strategy subscale was .16 which indicated a medium effect size and lastly the eta squared for planning subscale was .14 which was a medium effect size. However; no statistical difference was observed for self-checking subscale. The prompts in the manual may end up an increasing in PSTs' awareness, cognitive strategy, and planning

4.1.3. Research Question 3: Was there a statistically significant change in PSTs learning environment in terms of supporting the development of metacognition?

When the participants' responses to the pre and post MOLES-S was compared, it was observed that statistical differences were obtained in metacognitive demands, student-student discourse and student voice. Estimated eta squared for metacognitive demand was .35 representing large effect size. Estimated eta squared for student-student discourse was .16 indicating medium effect size and finally estimated eta squared for student voice was .15 representing medium effect size.

Descriptive analysis showed an increase for each MOLES-S scale except student teacher discourse. However, t-test analysis revealed a statistical difference for metacognitive demands, student-student discourse and student voice subscales.

4.2. Qualitative Results

This section presents the qualitative results for each case.

To be able to present qualitative results in an understandable way, the quotation tables were added into the appendices. The reader should read the frequency result tables with the related appendix table. In order to being clear, the appendices which should be followed in result chapter were explained below.

Appendix E presented the tables including each PST's quotations for the codes of their learning strategies and the metacognitive components which were revealed from their learning strategies quotation. There was also a column named "our interpretation". This column helped the reader understand how the researcher coded metacognitive knowledge and skills. For example in Selin case the first learning strategy was rhymes. The next column was metacognitive knowledge and skill which represented the metacognition component revealing from the quotation for the learning strategy. In this example metacognitive component for rhymes was declarative knowledge. It showed that the PST used her declarative knowledge while she was talking about rhyme strategy. The last column was our interpretation. This column explained how researcher coded the component as declarative knowledge.

Appendix F presented the tables including each PSTs' metacognitive knowledge and skills revealed from their pre-interview. The frequency tables were created according to these tables for each case. For example in Appendix F in Selin case, the reader can see the quotations for metacognitive components revealed from pre-interview. The frequency table for metacognitive components summarized how much each component was revealed from the interview. For example in Selin case, declarative knowledge was revealed 3 times in Table 4.13 and the reader can see the quotations in Appendix F.

Appendix G presented the tables including each PSTs' metacognitive knowledge and skills revealed from post interview. The frequency tables were also constructed regarding to this appendix as well. At last, Table 4.20 was presented as a summary table

to show each case's learning strategies and their metacognitive knowledge and skills revealed from pre and post interview.

4.2.1 Research Question 4: What kind of learning strategies and metacognitive knowledge and skills did PSTs have before the course?

While the tables for learning strategies were created, the codes for learning strategies were investigated and categorized according to the learning categories of Weinstein and Mayer (1983). For example in Selin case, rewriting, skimming and repeating to someone codes were revealed and these 3 codes were classified under the category of complex rehearsal strategy. Table 4.20 showed the frequency of learning strategy as well. In this case, the frequency for complex rehearsal strategy was 3 for Selin case. It means that this case reported 3 kinds of learning strategy codes under complex rehearsal strategy. The reader can look at Appendix E to see the quotations of the codes for learning strategies.

CASE1: SELIN

Quotations for the codes of learning strategies Selin used were attached in Appendix E. In addition to this, the quotations for metacognitive knowledge and skills revealed from pre interview can be seen in Appendix F.

Table 4.1 showed the codes and categories for learning strategy. Besides, this table showed the metacognitive knowledge and skills of her while she was explaining her learning strategies.

Table 4.6 Learning strategy codes and categories with metacognitive knowledge and skills for Selin case

Categories for learning strategy	Codes for learning strategy	Metacognitive Knowledge and Skills
Complex Rehearsal strategy	Rewriting	Procedural knowledge
	Skimming	Conditional knowledge
	Repeating to someone	Declarative knowledge
Basic Elaboration strategy	Rhymes	Declarative knowledge
Basic Organizational strategy	Organizing	Procedural knowledge
Comprehension monitoring strategy	Self- questioning	Conditional knowledge & Evaluation

In terms of learning strategies, of eight learning strategies, she reported six learning strategies regarding which were categorized under complex rehearsal, basic elaboration, basic organizational and comprehension monitoring strategies. According to Table 4.6, she reported three kinds of learning strategies under complex rehearsal strategy. As a result, she mostly reported complex rehearsal strategy. A representative example for complex rehearsal strategy was:

> For example, learning theories is our new homework. I hate memorizing, at least the social subjects. There were summaries, I read them. Then I looked some theorists like Piaget. I wrote who is Piaget then some steps were arisen. Then I returned back and wrote them again and revise them.

While she was explaining her learning strategies, it was observed that she used three types of metacognitive knowledge and evaluation metacognitive skill.

In terms of metacognitive knowledge, when her whole pre-interview was investigated, it was observed that she reported three kinds of metacognitive knowledge. Table 4.20 showed the frequency of metacognitive knowledge and the frequencies of metacognitive knowledge types were almost the same. It may be concluded that she

knew when and why to use a strategy. Below, there was a quotation which represented this idea:

> For example if it is biology, organizing knowledge is difficult. For example, a new chapter takes a lot of time and besides, since it is in English, perceiving them in your mind takes long time. Therefore, I start with the summaries which are at the end of the chapter. Some words were written in bold there; I look the definition of these terms. Then a picture can take my interest and I read the under the picture. Then I have knowledge for the related subject.

This quotation indicated that she differentiate the conditions for learning strategies. If organization of knowledge was difficult for her and she looked for the keywords and then examined the pictures. She organized her knowledge in biology in this way. In mean time, she used rhymes strategy to memorize very long things.

In terms of metacognitive skills, according to Table 4.20, except for planning skill she reported other two skills in pre-interview. As a learner it may be said that she had an ability to monitor and evaluate her learning. The quotations which represented of that idea were showed below:

> When somebody asks me a question for example related to force. I organize the knowledge by questions and answers, like what is force, what does it depends on.

> When I tell something to myself, I'm aware of the sentences. Why is it in this way, why is it like this? Then I search. When I tell the topic myself, I notice what I do not understand and I turn back and look again.

To sum up, she reported 6 learning strategies. Of these 6 learning strategies 3 of them were complex rehearsal strategies. It was observed that she reported three kinds of metacognitive knowledge in the explanation of the learning strategies. When the whole pre interview was investigated, she reported metacognitive knowledge in her pre

interview 8 times and in terms of metacognitive skills, she reported monitoring and evaluation skills.

CASE 2: DENIZ

Quotations for the codes of learning strategies Deniz used were attached in Appendix E. In addition to this, the quotations for metacognitive knowledge and skills revealed from pre interview can be seen in Appendix F.

Table 4.7 showed the codes and categories for learning strategy. Besides, this table showed the metacognitive knowledge and skills of her while she was explaining her learning strategies.

In terms of learning strategies, of eight strategies, she reported three kinds of learning strategies. According to Table 4.7, these strategies were complex rehearsal, complex elaboration and affective and motivational strategies.

While she was explaining her learning strategies, it was observed that she mostly reported procedural knowledge in her strategies. It may be concluded that she know how to use these learning strategies. But she did not mention conditional knowledge which referred to why and when to use these learning strategies. A representative quotation for procedural knowledge in her learning strategy was:

> I'm linking the topic with something in daily life…For example; linking the function of organelles with people working in a factory who are producing, delivering, digesting…

Table 4.7 Summary of learning strategies and metacognitive knowledge & skills for Deniz case

Categories for learning strategy	Codes for learning strategy	Metacognitive Knowledge and Skills
Complex Rehearsal strategy	Rewriting	Declarative knowledge
Complex Elaboration strategy	Analogy	Procedural knowledge
Affective and Motivational Strategy	Motivating herself	Procedural knowledge

In terms of metacognitive knowledge, according to Table 4.20 she reported three kinds of metacognitive knowledge in pre-interview. Among metacognitive knowledge, conditional knowledge was the least reported. It may be concluded that although she knew what she knew and how to apply her knowledge, she had some difficulty in when and why to use her knowledge.

In terms of metacognitive skills, she did not mention planning monitoring or evaluation skills. It may be concluded that she was not planning, monitoring and evaluating her learning.

CASE 3: ELA

Quotations for the codes of learning strategies that Ela used were attached in Appendix E. In addition to this, the quotations for metacognitive knowledge and skills revealed from pre interview can be seen in Appendix F.

Table 4.8 showed the codes and categories for learning strategy. Besides, this table showed the metacognitive knowledge and skills of her while she was explaining her learning strategies.

Table 4.8 Summary of learning strategies and metacognitive knowledge & skills for Ela case

Categories for learning strategy	Codes for learning strategy	Metacognitive Knowledge and Skills
Complex Rehearsal strategy	Rewriting	Procedural Knowledge
	Underlining	
	Skimming	Procedural Knowledge
Basic Elaboration strategy	Forming a phrase	Procedural Knowledge

In terms of learning strategies, she reported four learning strategies which were categorized under complex rehearsal strategy and basic elaboration strategy. According to Table 4.8, Ela mostly used complex rehearsal strategy which includes rewriting, underlining and skimming strategies. The other strategy she used was basic elaboration strategy which includes forming a phrase strategy. A representative example for complex rehearsal strategy was:

If it is biology, I look at the figures which summarize the topic.

While she was explaining her strategies, it was observed that she reported procedural knowledge. In other words, she explained how she used these strategies. A representative example for procedural knowledge was:

> One of my friends did not understand something in organic chemistry. There were numbers you know; one is mono three is tre. She did not understand 5 is penta. I made a weird linking. Penta was reminding me penti which was a sock brand. We wear sock to our foot and it has five fingers. Five is penta.

In terms of metacognitive knowledge, when her whole pre-interview was investigated, it was observed that she mostly reported procedural knowledge and she did not report conditional knowledge in pre-interview. Table 4.20 showed the frequency of metacognitive knowledge and skills. It may be concluded that she knew how to use her knowledge but did not aware of when and why to use her knowledge.

In terms of metacognitive skills, according to table 4.20, she did not declare any metacognitive skill. It may be suggested that she was not able to plan, monitor and evaluate her learning.

CASE 4: DIDEM

Quotations for the codes of learning strategies that Didem used were attached in Appendix E. In addition to this, the quotations for metacognitive knowledge and skills revealed from pre interview can be seen in Appendix F.

Table 4.9 showed the codes and categories for learning strategy. Besides, this table showed the metacognitive knowledge and skills of her while she was explaining her learning strategies.

Table 4.9 Summary of learning strategies and metacognitive knowledge & skills for Didem case

Categories for learning strategy	Codes for learning strategy	Metacognitive Knowledge and Skills
Basic Rehearsal strategy	Repeating by herself	Procedural Knowledge

In terms of learning strategies, according to Table 4.9, she reported one learning strategy which was basic rehearsal strategy. She declared procedural knowledge while she was explaining her learning strategy.

In terms of metacognitive knowledge, when her whole pre-interview was investigated, it was observed in the Table 4.20 that three types of metacognitive knowledge were reported once.

In terms of metacognitive skills, when her whole pre-interview was investigated, according to Table 4.20 she did not report metacognitive skill in her interview which may indicate that she was not able to plan, monitor and evaluate her learning.

CASE 5: ADA

Quotations for the codes of learning strategies that Ada used were attached in Appendix E. In addition to this, the quotations for metacognitive knowledge and skills revealed from pre interview can be seen in Appendix F.

Table 4.10 showed the codes and categories for learning strategy. Besides, this table also showed the metacognitive knowledge and skills of her while she was explaining her learning strategies.

Table 4.10 Summary of learning strategies and metacognitive knowledge & skills for Ada case

Categories for learning strategy	Codes for learning strategy	Metacognitive Knowledge and Skills
Complex Rehearsal strategy	Rewriting	Declarative Knowledge
Basic Elaboration strategy	Mental image	Conditional Knowledge
Complex Elaboration strategy	Paraphrasing	Procedural Knowledge
	Linking topics with examples	Procedural Knowledge
Comprehension monitoring strategy	Self-questioning	Monitoring
Affective and Motivational Strategy	Motivational strategy	Procedural Knowledge

In terms of learning strategies, it was found that she had six learning strategies which were categorized under complex rehearsal strategy, basic elaboration strategy, complex elaboration strategy, comprehension monitoring strategy and affective and motivational strategy. These learning strategies were diverse.

She reported three types of metacognitive knowledge and monitoring skill while she was explaining her learning strategies. She mostly reported procedural knowledge in her learning strategies. From this view, it may be concluded that she mostly interested in

how she used these learning strategies. Representative example for procedural knowledge was:

> I can read then make inference and write my own thoughts. I can write my own evaluation which is useful for me.

A representative example for conditional knowledge was:

> I may not understand a topic sufficiently via reading but learning this via a video or a visual schema is much easier for me and it would be more permanent knowledge. Listening the topic from a lecturer or an expert is not sufficient for me, I should see the process. Visual images are important for me.

In terms of metacognitive knowledge, when her whole pre-interview was investigated, it was observed that she reported three kinds of metacognitive knowledge. According to Table 4.20, she mostly reported declarative knowledge and she reported conditional knowledge least. It may be concluded that she knew what she knew and how she used her knowledge but she had little idea about why and when to use her knowledge.

In terms of metacognitive skills when her whole pre-interview was investigated, it was observed that she reported monitoring and planning skill. The quotation representing monitoring skill was:

> When I start a new topic, I'm questioning how much I connect this topic with my old learning. The thing I should learn is so much and for example I learn ¼ percent and I'm asking myself whether I can make a connection between the rest and the ¼ percent I have learnt and I'm questioning how much I can apply my learning sometimes.

Representative quotation for planning skill was:

> I'm deciding on the method that I will study with. I think on time when I will study."

It may be concluded for this case that she was able to plan and monitor her learning but she may not be able to evaluate her learning.

CASE 6: GAMZE

Quotations for the codes of learning strategies that Gamze used were attached in Appendix E. In addition to this, the quotations for metacognitive knowledge and skills revealed from pre interview can be seen in Appendix F.

Table 4.11 showed the codes and categories for learning strategy. Besides, this table showed the metacognitive knowledge and skills of her while she was explaining her learning strategies.

Table 4.11 Summary of learning strategies and metacognitive knowledge & skills for Gamze case

Categories for learning strategy	Codes for learning strategy	Metacognitive Knowledge and Skills
Basic elaboration strategy	mental image	Declarative Knowledge

In terms of learning strategies, she reported only one learning strategy which was categorized under basic elaboration strategy. While she was explaining her learning strategy, it was observed that she used declarative knowledge. It may be concluded that she only gave knowledge about the strategy and did not explain how to use, why and when to use this learning strategy.

In terms of metacognitive knowledge, when her whole pre-interview was investigated, it was observed that she reported declarative knowledge and conditional knowledge. Representative example for declarative knowledge was:

> For example, I do not write the part of the cell. I write it as a schema. I mean, the figures are important for me. Maybe I have many figures in my store of knowledge.

In terms of meatcognitive skills, when her whole pre-interview was investigated, it was observed that she did not declare any metacognitive skill. It may be concluded that she was not be able to plan, monitor and evaluate her learning.

CASE 7: BUSE

Quotations for the codes of learning strategies that Buse used were attached in Appendix E. In addition to this, the quotations for metacognitive knowledge and skills revealed from pre interview can be seen in Appendix F.

Table 4.12 showed the codes and categories for learning strategy. Besides, this table showed the metacognitive knowledge and skills of her while she was explaining her learning strategies.

Table 4.12 Summary of learning strategies and metacognitive knowledge & skills for Buse case

Categories for learning strategy	Codes for learning strategy	Metacognitive Knowledge and Skills
Basic Elaboration strategy	Mental Image	Procedural Knowledge
Comprehension monitoring strategy	Self- Questioning strategy	Procedural Knowledge
Affective and Motivational strategy	Motivating herself	Procedural Knowledge

In Buse case, she reported three learning strategies which were categorized under basic elaboration strategy, comprehension monitoring strategy and affective and motivational strategy. While she was explaining her strategies, she used procedural

knowledge. A representative example for procedural knowledge in the explanation of learning strategy was:

> I learn by asking a lot of questions, I have this learning style. I have lots of questions. I do not think that these questions are difficult, easy, logical or illogical. Maybe I'm too boring by asking many questions but I think sometimes I'm asking good questions. If I have questions related to the new topic that I could not answer by myself, I cannot learn that topic. First of all, all the questions I have should be answered.

In this example she reported self questioning strategy and explained how she used this learning strategy. It may be concluded that while she was explaining her learning strategy, she explained how to use it but did not mention anything about when and why to use her learning strategies.

In terms of metacognitive knowledge, when her whole pre-interview was investigated, it was observed that she reported three types of metacognitive knowledge. According to Table 4.20, she mostly reported procedural knowledge. A representative example for procedural knowledge was:

> If I cannot make a connection with my old knowledge, I try to learn the second part and try to make connection between two parts. If there is no connection with my old knowledge, daily life or to be learned things, learning this knowledge is too difficult.

In terms of metacognitive skills, when her whole pre-interview was investigated, it was observed that she did not report any metacognitive skill in her pre interview. It may be concluded that she was not be able to plan, monitor and evaluate her learning.

To sum up, the results attained from pre interview about metacognitive knowledge, metacognitive skills and learning strategies of PSTs are summarized below

- It was observed that among 7 PSTs, 3 of them reported comprehension monitoring strategy and from these 3 PSTs, two of them (Selin and Ada) reported metacognitive skills. Selin and Ada reported more learning strategies than the other PSTs. The rest of the PSTs did not report any metacognitive skills in their pre interview. Besides, monitoring skill is reported by only Selin and Ada.
- Ada had more various strategies than the rest. And she was the one who reported planning skill in the interview. Besides; she reported one monitoring skill. However, she did not report any evaluation skills.
- Selin was the one who reported evaluation skills. She was also one of the PSTs who reported more learning strategies than the others.
- Didem and Gamze reported only one learning strategy and they reported less learning strategies than the others. They also reported less metacognitive knowledge than the others and they did not report any metacognitive skills.
- Complex organizational strategy was not reported by any of the PSTs. The rest of the strategies were reported at least one PST. Complex rehearsal strategy was the most reported strategy, whereas basic rehearsal strategy and basic organizational strategy was less reported strategies by PSTs.
- Declarative knowledge was reported more than the other metacognitive knowledge. Conditional knowledge reported less than the other metacognitive knowledge.
- Planning and evaluation are the less reported metacognitive skills.
- While PSTs were talking about their learning strategies, only Ada and Selin reported metacognitive skills. Selin reported evaluation skill in comprehension monitoring strategy and Ada reported monitoring strategy in comprehension monitoring strategy. Both PSTs reported metacognitive skill in the same learning strategy. Buse is the other PST who reported comprehension monitoring strategy but she reported procedural knowledge in this strategy.

4.2.2 Research Question 5: How did the PSTs' metacognition change as a result of the course?

In order to answer this research question, PSTs' answers to pre and post interview questions were compared. Differently from pre interview, questions for learning strategies were not asked in post interview. Additionally, differently from pre interview, PSTs' thoughts for the laboratory manual were asked in the post interview. This question asked since it was wondered that whether they would use metacognitive knowledge and skills while answering the questions. There were also common questions in pre interview and post interview like how did they control their learning, how did they evaluate their learning.

Quotations for PSTs' metacognitive knowledge and skills revealed from pre-interview can be seen in Appendix F and the quotations for their metacognitive knowledge and skills from post interview can be seen in Appendix G. The frequency tables of metacognitive knowledge and skills were formed for each case according to Appendix F and Appendix G.

CASE1: SELIN

Table 4.13 showed the frequency of metacognitive knowledge and skills for Selin case. For example, she reported declarative knowledge 3 times in her pre interview. The quotations can be read in Appendix F for pre interview and in Appendix G for post interview.

Table 4.13 Frequency of metacognitive knowledge and skills in pre and post interviews revealed from Selin case

metacognitive knowledge in Pre-interview		**metacognitive skill in Pre-interview**		**metacognitive knowledge in Post-interview**		**metacognitive skill in Post-interview**	
Declarative knowledge	3	Planning	0	Declarative knowledge	5	Planning	0
Procedural Knowledge	2	Monitoring	2	Procedural Knowledge	5	Monitoring	4
Conditional Knowledge	3	Evaluation	1	Conditional Knowledge	3	Evaluation	4
TOTAL	**8**		**3**		**13**		**8**

In Selin case, it was found that there was an increase in both metacognitive knowledge and skills in her post interview.

In terms of metacognitive knowledge, there was an increase in declarative knowledge and procedural knowledge. There was not a change in conditional knowledge. She reported conditional knowledge three times in her both pre interview and post interview. A representative example for declarative knowledge was:

> I mostly used flowing charts while I was evaluating my learning in this course.

In this example she knew what strategy she used to evaluate her learning.

A representative example for procedural knowledge was:

> I reorganized my knowledge in this course. Because we used to memorize the definition but with the help of examples and discussions I learned better here and reorganized my knowledge in this way. For example I considered subjectivity as a top concept which includes the other aspects of Nature of science. I mean subjectivity includes creativity, tentativeness and the other aspects. I reorganized nature of science aspects in this way. According to me, Aspects of nature of science referred six or seven branches before but now I organized other aspects as components of subjectivity.

In this example she told how she reorganized her nature of science knowledge.

A representative example for conditional knowledge was:

> Our learning styles are different. I have learned many things from my friends by discussing and making experiments. Therefore this laboratory course contributed to my learning.

In this example she gave the reasoning why she found the course useful.

In terms of metacognitive skills, when pre and post interviews were compared, it was found that the frequency of monitoring and evaluation skills increased in her pre interview. A representative example revealed from her post interview for monitoring skill was:

> Because we had ideas in our mind and at the beginning we wanted to conduct the experiment instantly and did not write the procedure. When we

had mistakes we could not find since there was not a procedure. Then we learned the importance of procedure and wrote it before the experiment. Even there was a huge difference between the initial and final procedure, we had a procedure and when we had mistake we know which step to turn back and change.

In this quotation there was an on-line awareness for the importance of writing procedure. Therefore, this quotation was classified as monitoring skill.

She had not reported any evaluation skill in her pre interview, whereas she reported it in her post interview. A representative example for evaluation skill was:

Science is more understandable now. I used to fear of science, especially in high school, I hated chemistry, physics and biology. But now, I have been able to do it. Therefore, it is more understandable and easy for me.

In this quotation there was a judgment for her view to science.

When it comes to planning skill, it was observed that she did not report this skill in her either pre interview or post interview.

CASE2: DENIZ

Table 4.14 showed the frequency of metacognitive knowledge and skills for Deniz case. For example, she reported declarative knowledge 2 times in her pre interview. The quotations can be read in Appendix F for pre interview and in Appendix G for post interview.

Table 4.14 Frequency of metacognitive knowledge and skills in pre and post interviews revealed from Deniz case

metacognitive knowledge in Pre-interview		**metacognitive skill in Pre-interview**		**metacognitive knowledge in Post-interview**		**metacognitive skill in Post-interview**	
Declarative knowledge	2	Planning	0	Declarative knowledge	4	Planning	1
Procedural Knowledge	2	Monitoring	0	Procedural Knowledge	5	Monitoring	10
Conditional Knowledge	1	Evaluating	0	Conditional Knowledge	3	Evaluation	5
TOTAL	**5**		**0**		**12**		**16**

In Deniz case, there was an increase in both metacognitive knowledge and metacognitive skill as Table 4.14 showed.

In terms of metacognitive knowledge, there was an increase in three categories of metacognitive knowledge. Three types of metacognitive knowledge were revealed from her post interview. A representative example for declarative knowledge was:

> The most amazing part was the last question which was related to evaluation. No matter how much grade I lost, the most amazing part was there.

In this example, she stated her propositional knowledge referring to what she thinks as a learner about one of the question in the manual.

A representative example for procedural knowledge was:

> While we were designing the procedure, we were discussing our individual procedure's lack points then we formed our group procedure by considering the discussions.

In this example she stated how they formed their group procedure.

A representative example for conditional knowledge in her post interview was:

> My confidence in science has increased in this course because I had not been active in the laboratory lessons. Even I did not use microscope when I was in high school. In terms of making experiment, managing these experiments, this laboratory course contributed me a lot of things. Now I'm thinking that I can manage better my future laboratory course as a teacher.

She gave her reasons for the increase in her confidence level throughout the current laboratory course.

In terms of metacognitive skills, she had not mentioned any of metacognitive skill, whereas she stated three types of metacognitive skills in her post interview. A representative example for planning was:

> We selected our materials, formed our procedure according to the hypothesis we thought.

She pointed out the selection of materials for the preparation of the experiment.

A representative example for monitoring was:

> Another different thing in this course was individuality. In our other lesson when we worked as a group, our individual thoughts were not asked. But in this course we wrote both our individual thought and individual experiment design and then compared them with group members'. This laboratory course was more detailed and four hours were not enough.

This quotation indicated monitoring skill since she compared the current laboratory course and the previous lessons. It was an on-line awareness of her for the different feature of the current laboratory course.

A representative example for the evaluation skill was:

> I think the questions in the manual were designed to make us think on question more detailed and to take our individual thoughts and comments. These things leaded us to find something different. For example we were asked to express our thought on evolution instead of regular questions including only theoretical knowledge.

She made a judgment about the objective of the manual. She evaluated the laboratory manual in this quotation.

Differently from other cases, Deniz reported planning skill in her interview.

CASE 3: ELA

Table 4.15 showed the frequency of metacognitive knowledge and skills for Ela case. For example, she reported declarative knowledge 2 times in her pre interview. The quotations can be read in Appendix F for pre interview and in Appendix G for post interview.

Table 4.15 Frequency of metacognitive knowledge and skills in pre and post interviews revealed from Ela case

metacognitive knowledge in Pre-interview		**metacognitive skill in Pre-interview**		**metacognitive knowledge in Post-interview**		**metacognitive skill in Post-interview**	
Declarative knowledge	1	Planning	0	Declarative knowledge	5	Planning	0
Procedural Knowledge	3	Monitoring	0	Procedural Knowledge	1	Monitoring	5
Conditional Knowledge	0	Evaluating	0	Conditional Knowledge	3	Evaluation	2
TOTAL	**4**		**0**		**9**		**7**

In Ela case, it was found that there was an increase in both metacognitive knowledge and metacognitive skills in her post interview.

In terms of metacognitive knowledge, there was an increase in declarative knowledge and conditional knowledge. However, there was a decrease in procedural knowledge according to table 4.15.

A representative example for declarative knowledge was:

> Up to now, nobody was interested in what I thought but in this lesson you have wondered what I think.

She pointed out her knowledge about the lecturer.

A representative example conditional knowledge was:

> I adjust myself according to the demand of the lecturer. If s/he wants me to memorize, I will memorize. If s/he wants me to think, I will think. Or if s/he wants me to carry out a project, I will do it.

This quotation referred to her allocation of her strategies according to the demand of the lecturer. Therefore, this quotation referred to conditional knowledge.

In terms of metacognitive skills, there was an increase in her post interview. She had not reported any metacognitive skill in her pre interview but she reported monitoring and evaluation skills in her post interview. A representative example for monitoring skill was:

> Questions in the manual required to think on deeply. I mean I tried to explain how I think. Yes I made a model but how I did and what inspired me. Then I questioned what I think and how I think.

It was her online awareness during the interview that she engaged in how she thought and how she made the model during the current laboratory course.

An example for evaluation was:

> …. most of the lesson wanted us to memorize everything. But with this course my thinking ability is getting better and I think on what I'm thinking and what I'm not thinking.

She made a judgment for her thinking development in the current course.

CASE 4: DIDEM

Table 4.16 showed the frequency of metacognitive knowledge and skills for Didem case. For example, she reported declarative knowledge 1 time in her pre interview. The quotations can be read in Appendix F for pre interview and in Appendix G for post interview.

Table 4.16 Frequency of metacognitive knowledge and skills in pre and post interviews revealed from Ela case

metacognitive knowledge in Pre-interview		**metacognitive skill in Pre-interview**		**metacognitive knowledge in Post-interview**		**metacognitive skill in Post-interview**	
Declarative knowledge	1	Planning	0	Declarative knowledge	10	Planning	0
Procedural Knowledge	1	Monitoring	0	Procedural Knowledge	2	Monitoring	7
Conditional Knowledge	1	Evaluating	0	Conditional Knowledge	4	Evaluation	3
TOTAL	**3**		**0**		**16**		**10**

In Didem case, it was found that there was an increase in both metacognitive knowledge and metacognitive skills revealed from their post interview.

In terms of metacognitive knowledge, there was an increase in three categories of metacognitive knowledge. Three types of metacognitive knowledge including declarative knowledge, procedural knowledge and conditional knowledge more reported in her post interview. A representative example for declarative knowledge was:

> While I was filling the manual, I had to check my pre-knowledge.

That was her knowledge for the task.

A representative example for procedural knowledge was:

> In the black box experiment, I remembered an experiment which I made in our method course. We opened three holes on the bottle and closed them

> with paraffin. When we opened the first hole, water did not flow but when the second hole was opened, water began to flow and if we filled water above the second hole, we would take more water than we put. We did it in the black box activity. Among a lot of individual models, my group decided to make my model and that made me very happy.

That was her knowledge about how she did her model in an activity being named as back box activity.

A representative example for conditional knowledge was:

> My learning in this laboratory course was more meaningful because we designed our experiments and made discussions related to the experiments and our learning. Everybody made different things and we examined them. Knowledge was more permanent with the help of these things. In terms of the learning, I prefer being active instead of reading slides in a course.

This quotation addressed the reasons why she thought the current laboratory course was meaningful for her.

In terms of metacognitive skills, there was an increase in her post interview. She had not reported any metacognitive skill in her pre interview, while she reported monitoring and evaluation skills in her post interview. A representative example from her post interview for monitoring skill was:

> Before taking this course, scientific articles did not interest me and I did not like reading them. However, I have liked reading them now. Even I buy scientific magazine now and try to improve myself.

That was an on-line awareness of her about the contribution of the current course to her.

A representative example for evaluation skill was:

> I have begun to question both scientific and nonscientific issues. My viewpoint has been changed.

CASE 5: ADA

Table 4.17 showed the frequency of metacognitive knowledge and skills for Ada case. For example, she reported declarative knowledge 4 times in her pre interview. The quotations can be read in Appendix F for pre interview and in Appendix G for post interview.

Table 4.17 Frequency of metacognitive knowledge and skills in pre and post interviews revealed from Ada case

metacognitive knowledge in Pre-interview		**metacognitive skill in Pre-interview**		**metacognitive knowledge in Post-interview**		**metacognitive skill in Post-interview**	
Declarative knowledge	4	Planning	1	Declarative knowledge	7	Planning	0
Procedural Knowledge	3	Monitoring	1	Procedural Knowledge	2	Monitoring	6
Conditional Knowledge	1	Evaluating	0	Conditional Knowledge	2	Evaluating	2
TOTAL	**8**		**2**		**11**		**8**

In Ada case, according to Table 4.17, it was found that there was an increase in both metacognitive knowledge and metacognitive skills revealed from their post interview.

In terms of metacognitive knowledge, there was an increase in declarative knowledge and conditional knowledge. However she reported less procedural knowledge in her post interview. She reported procedural knowledge for three times in her pre interview but she reported it two times in her post interview. A representative example for procedural knowledge was in her post interview was:

> I evaluated my learning in ratings and the diagram models that I draw at the end of the lesson.

A representative example for conditional knowledge was:

> For example if we rate ourselves as 4 or 3 out of 5 but why? Writing the reasons of this was more effective and I think that part was the most difficult. Actually, how accurate scientific knowledge is. Therefore, I have never rated myself as 5. I have always doubt but there were also some evidences. Due to these reasons, I both evaluate the evidences and consider the tentativeness feature of science while rating myself, my method or

> models. As a result, I neither rated myself as “not very confident” nor “very confident”. She gave the reasons why she did not rate herself as 5 out of 5.

In terms metacognitive skills, there was an increase in her monitoring and evaluation skill while there was a decrease in her planning skill. A representative example for monitoring skill was:

> This course helped me to be aware of the lack points. For example I did not have knowledge about the theories, I did not know what observation means or I did not have enough knowledge for evolution theory. In addition, this course provided me an environment to test my knowledge.

It was an on-line awareness of her she explored during the current course that she had some lack knowledge.

A representative example for evaluation was:

> Questions for concept maps and diagrams were very good. Firstly I did not designed good things but later I have developed them by thinking on them deeply and produced different things. I do not think I’m very creative and these questions are partly related to creativity. For example firstly I used flowing charts but later I used pictures to express my evaluation. I think there was a change and improvement in the way of my evaluation type. I think this evaluation question is a type of summary which reflects what we learned throughout the lesson and we can evaluate and question ourselves about our learning. It was an effective method, I think.

She made an evaluation about her answer to last question and concluded that there was an improvement for her in terms of the way of expressing her learning.

CASE 6: GAMZE

Table 4.18 showed the frequency of metacognitive knowledge and skills for Gamze case. For example, she reported declarative knowledge 2 times in her pre interview. The quotations can be read in Appendix F for pre interview and in Appendix G for post interview.

Table 4.18 Frequency of metacognitive knowledge and skills in pre and post interviews revealed from Gamze case

metacognitive knowledge in Pre-interview		**metacognitive skill in Pre-interview**		**metacognitive knowledge in Post-interview**		**metacognitive skill in Post-interview**	
Declarative knowledge	2	Planning	0	Declarative knowledge	9	Planning	0
Procedural Knowledge	0	Monitoring	0	Procedural Knowledge	1	Monitoring	3
Conditional Knowledge	1	Evaluating	0	Conditional Knowledge	2	Evaluating	0
TOTAL	**3**		**0**		**12**		**3**

In Gamze case, there was an increase in both metacognitive knowledge and metacognitive skill as Table 4.18 showed.

In terms of metacognitive knowledge, there was an increase in three categories of metacognitive knowledge. Three types of metacognitive knowledge were revealed from her post interview. A representative example for metacognitive knowledge was:

> This course not only gave theoretical knowledge but also gave the implication of nature of science.

It was her knowledge about the task.

A representative example for procedural knowledge was:

> We evaluated ourselves very much in this laboratory course. I was questioning how much our knowledge was right or wrong and how much confident I was. Actually there was a fact that if you did not make somebody something, s/he never did it. Although ratings were forced us, it was a good way to question our knowledge. It had to be in this way.

In that quotation she gave knowledge of how she evaluated herself in the current laboratory course.

A representative example to conditional knowledge was:

> In addition to ratings, I had difficulty in the last question which includes showing our learning on a diagram or concept map. That question required us to be creative and I thought that I was not enough creative to answer that question properly. I lost most of grade in that question

She gave her reasoning about why she had difficulty in the last question in the manual. In terms of metacognitive skills, she had not reported any metacognitive skill in her pre interview while she reported monitoring skill in her post interview.

A representative example for monitoring skill revealed from her post interview was:

> I think the most enjoyable part was discussions because I like talking and listening other people's thoughts. I could support my ideas or I could change my thoughts if my friends refuted me. Thanks to discussions I was aware of the different thoughts.

CASE 7: BUSE

Table 4.19 showed the frequency of metacognitive knowledge and skills for Buse case. For example, she reported declarative knowledge 6 times in her pre interview. The quotations can be read in Appendix F for pre interview and in Appendix G for post interview.

Table 4.19 Frequency of metacognitive knowledge and skills in pre and post interviews revealed from Buse case

metacognitive knowledge in Pre-interview		**metacognitive skill in Pre-interview**		**metacognitive knowledge in Post-interview**		**metacognitive skill in Post-interview**	
Declarative knowledge	6	Planning	0	Declarative knowledge	8	Planning	0
Procedural Knowledge	2	Monitoring	0	Procedural Knowledge	4	Monitoring	10
Conditional Knowledge	1	Evaluating	0	Conditional Knowledge	7	Evaluating	5
TOTAL	**9**		**0**		**19**		**15**

In Buse case, it was found that there was an increase in both metacognitive knowledge and metacognitive skills in her post interview.

In terms of metacognitive knowledge, there was an increase in the frequency of declarative knowledge, procedural knowledge and conditional knowledge. A representative example to declarative knowledge was:

> There were questions in the manual aimed to detect our pre knowledge for the topic and they were also open to discussion. Additionally, they leaded us to interpret our knowledge.

This quotation was her knowledge for the manual.

A representative example to procedural knowledge was:

> Activities and experiments were very useful to control my knowledge. For example when I was failed in something, I had chance to overcome this failure. I could make this correction in experiment or in group discussion or in the middle of the lesson that I asked a question or your questions helped me overcome my failure. I could both control my knowledge and corrected the misconceptions in this way.

This quotation showed how she controlled her learning during the current course.

A representative example to conditional knowledge was:

> In the course, at the end of the question, both misconceptions could be detected and our learning could be summarized. The things that I could include into my concept maps were the permanent knowledge for me. Therefore, this part was very good to evaluate my own learning.

In terms of metacognitive skills, she had not reported any metacognitive skill in her pre interview, whereas she covered monitoring and evaluation skills in her post interview. A representative example to monitoring skill was:

> In our other lessons, it was expected from us to write the same things. For example hypothesis. The lecturer wanted us to write the same hypothesis. But in this course, it depended on me and there were a lot of alternative hypothesis I could write. It depended on my creativity and multidimensional thinking. I had my data and hypothesis and I was free to express my thought.

A representative example to evaluation skill was:

> Generally I was unsuccessful in the last question in the manual. Sometimes I took my feedback late from you. I wish I could have been taken my feedback in time. Maybe if I did it, I would have been more successful and developed my concept map and diagram.

Table 4.20 Summary of the cases' learning strategies, metacognitive knowledge and skills revealed from pre and post interview

		SELIN		DENIZ		ELA		DIDEM		ADA		GAMZE		BUSE	
LEARNING STRATEGIES	Basic Rehearsal S.	0		0		0		1		0		0		0	
	Complex Rehearsal S.	3		1		3		0		1		0		0	
	Basic Elaboration S.	1		0		1		0		1		1		1	
	Complex Elaboration S.	0		1		0		0		2		0		0	
	Basic Organizational S.	1		0		0		0		1		0		0	
	Complex Organizational S.	0		0		0		0		0		0		0	
	Comprehension Monitoring Strategy	1		0		0		0		1		0		1	
	Affective and Motivational Strategy	0		1		0		0		1		0		1	
TOTAL		**6**		**3**		**4**		**1**		**6**		**1**		**3**	
		pre	**post**	**pre**	**post**	**pre**	**post**	**pre**	**post**	**pre**	**post**	**pre**	**post**	**pre**	**post**
METACOGNITIVE KNOWLEDGE	Declarative Knowledge	3	5	2	4	1	5	1	10	4	7	2	9	6	**8**
	Procedural Knowledge	2	5	2	5	3	1	1	2	3	2	0	1	2	**4**
	Conditional Knowledge	3	3	1	3	0	3	1	4	1	2	1	2	1	**7**
TOTAL		**8**	**13**	**5**	**12**	**4**	**9**	**3**	**16**	**8**	**11**	**3**	**12**	**9**	**19**
METACOGNITIVE SKILLS	Planning	0	0	0	1	0	0	0	0	1	0	0	0	0	**0**
	Monitoring	2	4	0	10	0	5	0	7	1	6	0	3	0	**10**
	Evaluation	1	4	0	5	0	2	0	3	0	2	0	0	0	**5**
TOTAL		**3**	**8**	**0**	**16**	**0**	**7**	**0**	**10**	**2**	**8**	**0**	**3**	**0**	**15**

As a result, it was observed that there was a general increase in both metacognitive knowledge and metacognitive skill in almost all cases. It may be said that PSTs' metacognition improved throughout the course. Metacognitive prompts in the manual may contribute to this change.

Especially the frequency of monitoring skill increased very much in all cases. Before the course, only Selin and Ada cases reported monitoring skill in the interview. After the course instruction, all PSTs reported monitoring skill in the interview. This result showed that PSTs monitor their learning in the course and they began to aware of their and their friends thinking. The quotations of post interview also supported this result as well.

In terms of evaluation skill, only Selin reported this skill in pre-interview. After the course except for Gamze case, all PSTs reported this skill in post-interview. The last question in the manual which asked for the evaluation of the course may contribute to this change.

4.2.3 Research Question 6: How did metacognitively embedded prompts help to create a metacognitively oriented learning environment in the science laboratory course?

To be able to answer this research question, the subscale of Thomas (2002)'s scale was used and PSTs' interview was analyzed according to this seven subscales. The researcher looked for whether the PSTs interview covered these subscales. The examples which met the definition of subscales were given in Table 4.21. The definition of subscales was given in the table as Thomas (2002) defined.

According to the quantitative result for metacognitive orientation scale (MOLE-S), There was a statistically significant increase in MOLES-S scores from pre test (M= 3.61, SD= .60) to post test (M= 4.06, SD= .59), $t(27)= 2.82$, $p<.05$ (two tailed) with a medium effect size. There was a statistically difference in the metacognitive demands, student-student discourse and student voice subscales. Although there was not a statistically significant result in the other subscales, the interviews with students showed that this laboratory course with metacognitively embedded prompts provided student-teacher discourse, distributed control, teacher encouragement and support and emotional support. Examples from interviews and field notes were given in Table 4.21 which showed the thoughts of PSTs about the laboratory course and the manuals.

Table 4.21 Evidences for providing metacognitively oriented classroom environment from PSTs' views in the interviews.

MOLES-S sub dimensions	The definitions of dimensions	The examples from the interviews
Metacognitive Demands	Students are aware of how they learn and how they can improve their science learning. Students think about their own thanking	**Ada:** I questioned my pre knowledge a lot in this course. I asked myself did I see this before, did I know this, how much things do I know about this topic? How much do I familiar with this? Do I have enough knowledge to make comments, inference and predictions? **Buse:** for example; what did we learn? Or how did Student G learn? And how did I learn, what did she understand, what did I understand?
Student- student discourse	Students discuss their science learning processes with each other	**Deniz:** For example we aim to reach the same thing but everybody in our group chooses a different way. For example Selin did something with physics, Ela thought something related with chemistry and Tolga thought totally different things. You can learn different things from all and combine these thoughts with yours and make some comments. **Buse:** For example sometimes I thought three or more hypothesis or sometimes I could write only one hypothesis then when we come to the group study, my group friends could say different hypothesis, I said wow!!! It is very interesting hypothesis, why did not I think like this. Then we decided on our group hypothesis. There was a good communication among us.
Student- teacher discourse	Students discuss their science learning processes with their teacher	**Ela:** During the activities we asked you that these are true? And you said that why do you think it is true? Actually you guided us, therefore, even if we were true, we thought on every detail and asked ourselves and we wondered if we missed something. You made contributions and this is nice. **Deniz:** We asked you whether we are true and we explained our thoughts. You told us that perceive your friends. This is really different.

Table 4.21 (continued)

Student voice	**Students can question the teacher's pedagogical plans and methods. They can decide on how to learn the lesson.**	Ela: **The application of this lesson is different. We made the experiment and see ourselves. We design the experiment individually and thought on it and we decided everything step by step and you have the chance to make mistakes and if we made mistakes, we turn back to correct it.**
Distributed control	Students collaborate with the teacher to plan their learning.	**Deniz:** The procedure was determined by us. The materials were chosen by us. We asked you whether we are true and you said that perceived your friends. It is totally different. The individualism is very much in here differently from other courses. In other courses we did and found what they wanted. … We both design individual and group experiment and compared them with other group members and then decided on the group model. There were lots of steps differently from other courses.
Teacher encouragement and support	Students are encouraged by the teacher to improve their science learning process.	**Ada:** Teacher, thanks for your support in this lesson, we could not draw the gene tree without your questions that leaded us.
Emotional support	Students are cared for emotionally and their ideas are respected	**Ela:** You really made me feel valuable because you did not neglect any idea of us even if it was not logical. Therefore I feel comfortable enough to express my opinions.

According to the interview with PSTs, it can be concluded that metacognitively learning environment was provided throughout the course. When the paired samples t-test of MOLE-s was examined it was also found that statistical significant difference was found in metacognitive demands, student-student discourse and student voice subcomponents. Except for student-teacher discourse, other components' scores increased as well. The reason why student-teacher discourse decreased may be the effect of inquiry based learning environment.

4.2.4 Research Question 7: What were the PSTs thoughts about the laboratory course with metacognitively embedded prompts?

The aim of asking this question was to provide the reader a detailed view about the learning environment. In addition to this aim, PSTs thought about the course was important as they participants of this current study.

The most common thought of them was that the question for the explanation of their rating was difficult for them. Representative quotation supporting this idea was:

> Deniz: I could rate myself but initially I had problems in the explanation of the ratings and I lost some grades in this part.

Although all PSTs thought that explanation of the rating was difficult, except for one case (Didem) they stated that this explanation was useful for them since this question leaded them question their knowledge and confidence level. Representative quotation for this idea was:

> Ada: The rating part helped me understand how much valid what I thought. I had some idea but what the basis were for these idea and how much confident I was. This question helped me criticize my knowledge and most of the time I was uncertain about my rating. I had some difficulty in that part.

Most of the PSTs stated that due to the current laboratory course, they questioned everything more detailed. Representative quotations for thus idea were:

> Buse: I have been questioning my observations more detailed. For example my viewpoint to the standing water on the road has been changed. One day I was walking with a friend and saw standing water on our way and I stopped

> and observed it. It was foamy and I began to thinking on why it was foamy. My friend forced me to go on our way and I reminded our lesson in the laboratory and talked about it to my friend.
>
> Ada: I think the content of the laboratory manual leaded me to question. It was not me to force myself thinking, questioning. I did not do these things by myself. If I could do this, I had done it in my previous laboratory lessons.

Most of the PSTs were aware one of our aim was their individual thought. Representative quotation for this idea was:

> Selin: I think you examined the progress as well. I mean you were looking for what we had thought individually, what we thought as a group, what we discussed and then what we decided on, whether we changed our idea or how we convinced the others.

All PSTs were aware of the different thoughts of their group friends and most of the PSTs were pleased with the individual questions. Representative quotations for this idea were:

> Didem: If you ask whether these individual questions were useful, yes they were useful for me. I forced myself to think and design something and I think that my individual thoughts have been developed.
>
> Buse: Communication in the lesson was very good. I really thought sometimes that I was perfect. I told myself that I made all observations, collected my data and made a perfect hypothesis. But then one of my group friend thought a better thing and I was surprised. I thought at that moment that how she thought this. Thinking firstly individually and as a group was very good.

In terms of evaluation of their own learning question, all PSTs thought that it was a good question to summarize their learning and detect the misconceptions. Representative quotations for this idea were:

> Didem: The last question in the manual contributed us to develop our creativity. I think the objective of that question was that. Besides, it provided us to revise and show what we learned with a summary.
>
> Gamze: Questions for concept maps and diagrams were very good. Firstly I did not designed good things but later I have developed them by thinking on

> them deeply and produced different things. I do not think I'm very creative and these questions are partly related to creativity. For example firstly I used flowing charts but later I used pictures to express my evaluation. I think there was a change and improvement in the way of my evaluation type. I think this evaluation question is a type of summary which reflects what we learned throughout the lesson and we can evaluate and question ourselves about our learning. It was an effective method, I think.

Deniz case stated that she integrated "drawing a diagram or a concept map for learning" question into her lesson plans. The quotation revealed from her interview that:

> The question that asked for drawing a diagram or concept map for our learning had not been asked in my previous lessons but I integrated this question to my lesson plans. For example as a quiz question I asked what they learned while making the experiment and I wanted them to show their learning on a diagram.

In addition to this integration Deniz also began to use this technique in her lesson as a method to study. The representative quotation was:

> I used concept map in physiology lesson to organize my knowledge. I took a big paper and I organized the assays or the paragraphs in the book as colorful diagram and hang it on my wardrobe. I keep knowledge in my mind in this way for this lesson.

However other participants did not report this situation.

All PSTs stated that their self confidence was increased in this course. Representative quotations for this idea were:

> Deniz: My confidence in science has increased in this course because I had not been active in the laboratory lessons. Even I did not use microscope when I was in high school. In terms of making experiment, managing these experiments, this laboratory course contributed me a lot of things. Now I'm thinking that I can manage better my future laboratory course as a teacher.

> Ela: Taking this course is useful for me in terms of both being a qualified teacher and changing my confidence level from negative to positive.

CHAPTER 5

DISCUSSION

In this chapter, discussion of results, implications and recommendations for further research were presented.

5.1 Discussion of results

This chapter is divided into three main titles. These titles are Pre service science teachers' (PSTs') learning strategies and their characteristics of metacognition, change of PSTs' metacognition as a result of the course and learning environment of the laboratory course with metacognitive prompts.

5.1.1 PSTs' Learning Strategies and Their Characteristics of Metacognition

According to Hofer, Yu and Pintrich (1998) college students have already formed their learning strategies to regulate their learning. They also use these learning strategies to deal with new knowledge. In this study, PSTs' learning strategies were wondered and investigated in pre-interview.

According to the results, it was found that Basic Elaboration strategy such as forming mental image and forming phrase was the most reported learning strategy. Of seven PSTs, five of them reported this learning strategy. According to Weinstein and Mayer (1983), basic elaboration strategy helps learners to construct the associations via mental image or forming phrases among several items. Elaboration strategy helps learners to build the connection between old and new knowledge. It may be concluded that PSTs who reported this strategy were able to construct relationships between their old and new knowledge.

Basic rehearsal strategy was reported by only one PST (Didem case). According to Weinstein and Mayer (1983) basic rehearsal strategy is the most common strategy used by learners. However the result of this study showed that basic rehearsal strategy was one of the least used strategies.

Complex organizational strategy such as outlining and constructing a hierarchy was not reported by any PST. Complex rehearsal strategy is important in terms of building the connection among new knowledge. Outlining, identifying main ideas in a text or organizing knowledge are strategies that the learners use while constructing the relations between new learning tasks (Weinstein & Mayer, 1983). It may be concluded that PSTs may have a problem in constructing this relations among new learning tasks. This result is consistent with the study of Shih, Ingebritsen, Pleasants, Flickinger and Georger (1998) who found that the lowest strategy that college students used was organizational strategy. The most common strategies these college students used were rehearsal and elaboration learning strategies. Elaboration and organizational strategies are important since they enable learners to learn concepts with constructing relationships. Learning concepts as separate elements is not an effective way (Pressley, Borkowski &Schneider, 1987).

When the cases were compared, it was observed that Selin and Ada reported more learning strategies than the rest. In addition, metacognitive skills were reported only by Selin and Ada before the course. The rest of the PSTs did not report any metacognitive skills. Didem and Gamze reported only one learning strategy and these cases reported less metacognitive knowledge and did not report any metacognitive skill before the course. It may be concluded from these results that metacognition and learning strategies have a relation and the more learning strategies may lead learners use more metacognitive skills.

5.1.2 Change of PSTs' Metacognition as a Result of the Course

Self awareness scale was used as a measurement for metacognition. Descriptive results of self awareness score revealed a general increase in all sub scale scores. The increase in awareness, cognitive strategy and planning was found statistically significant. The effect size was at medium level. Awareness subscale was an indicator of the self-consciousness of the learning process. Based on these results, it may be concluded that PSTs became aware of their learning process in the laboratory course.

Cognitive strategy subscale included the cognitive or affective strategy to monitor learning. PSTs' learning strategies also investigated before the course application. It was found that some PSTs had various learning strategies whereas; some had very few learning strategies. PSTs' learning strategies after the course were not investigated but a significant change in cognitive strategy was found. According to Hofer, Yu and Pintrich (1998) college students have already formed their learning strategies. Therefore, it was thought that these PSTs have already formed their learning strategies as well. It may be concluded from the significant change in cognitive strategy subscale that this course also contributed to the awareness of PSTs' learning strategies.

Planning subscale includes learners' plan to achieve goal. There was a significant increase in PSTs' planning score as well. It may be concluded that their planning skill improved in the course. The last sub component was self-checking. An increase was also found in this subcomponent but this increase was not statistically significant. Self-checking is the monitoring of learning. Due to the increase in the score of this component, it may be concluded that PSTs' monitoring ability was also improved throughout the course.

It may be concluded from the quantitative data of the study that this course may contribute to PSTs' awareness, cognitive strategy, planning and self-checking. O'Neil and Abedi (1996) who developed the self-awareness scale stated that this scale was developed to measure metacognition. Due to the increase in all subcomponents, it can be concluded that this course which included metacognitive prompts developed PSTs'

metacognition. Literature included the examples for the success of metacognitive prompts. The study of Mevarech and Fridkin (2006) included prompts for the development of metacognition, mathematical knowledge and reasoning ability. The results showed that the experimental group who received these prompts outperformed the control group.

The results of the qualitative data showed that both metacognitive knowledge and metacognitive skills of PTSs were improved. In terms of metacognitive knowledge, conditional knowledge was the less reported metacognitive knowledge type before the course. However, the increase was the most in conditional knowledge after the course. Conditional knowledge is an answer to why and when question. This type of metacognitive knowledge type enable learner to be aware of the reasons for her/his decisions. Besides of this, conditional knowledge is related to know when to apply declarative and procedural knowledge. It can be concluded that the manual contributed to the development of PSTs' conditional knowledge. Prompts to provoke and to develop PSTs' conditional knowledge were embedded to the manual. From the qualitative results it may be concluded that these prompts worked for the PSTs. The increase in declarative knowledge and procedural knowledge was also observed. Declarative knowledge is the learner's knowledge about herself/himself as a learner. An increase in declarative knowledge can be a result of those that PSTs began to know more about their strengths, weaknesses and their thoughts related to science contexts in the course. An increase in procedural knowledge was observed except for two cases (Ela and Ada). Procedural knowledge is the knowledge about how to do things step by step. Laboratory environment with experiments is appropriate to enhance this metacognitive knowledge type. Laboratory manual also included the prompts to enhance procedural knowledge. As other 5 PSTs' reported procedural knowledge increased, it can be concluded that this course also contributed to the development of this metacognitive type.

In terms of metacognitive skills, of seven PSTs, only Selin and Ada cases reported metacognitive skills before the course. Selin reported monitoring and evaluation skills and Ada reported planning and monitoring skills. The rest did not report any metacognitive skill.

Planning skill was reported only by Deniz case. The rest of the PSTs did not report this skill. This result was interesting because quantitative data showed that PSTs' planning skill was developed. However, of seven PSTs, six of them did not report this skill in the interview. Laboratory manual also included prompts for planning skill. Although they developed this skill, they may not aware of it. Therefore, they did not report it in their post interview. Based on the quantitative data and the PSTs' responses to prompts in the manual, it can be concluded that PSTs' planning skill was also developed in this study. However, the reasons for why they did not report planning in their interview can be investigated in detail in future research.

After the course, all PSTs mentioned monitoring skill. From the quantitative data, it was found that PSTs' both awareness and self-checking scores increased and the increase in awareness was found statistically significant. The definition of both two subscales is matching up with monitoring skill as O'neil and Abedi (1996) defined self-checking as monitoring of learning and they defined awareness as self-consciousness. Monitoring skill is the on-line awareness of learning and being aware of the other people's learning style and knowledge as well (Pintrich, 1999; Pintrich, 2002; Yürük, 2005). As a result of the definitions it can be thought that monitoring skill include these two components of self-awareness. From this view, quantitative and qualitative data support each other regarding to the development in monitoring skill. Laboratory manual also included prompts for monitoring skill and from this result it can be concluded that these prompts worked for the development of PSTs' metacognition. Kramarski and Gutman (2006) used prompts for metacognition in e-learning environment and they found that students who received prompts to develop metacognition used monitoring

skill more than the other students who did not received metacognitive prompts. Introducing prompts for monitoring skill is crucial since it was reported that neither children nor adult learners monitor their learning (Pressley et al, 1987). Qualitative results of this study before the course supported this conclusion as well.

In terms of evaluation skill, except for one case (Gamze), six PSTs reported evaluation skill after the course. Therefore, it can be concluded that PSTs' evaluation skill was also developed throughout the course. Davis (2003) suggested that small groups discussion including collaborative works, peer models provided students promote their metacognition. Our course also included small groups and the manual included prompts for individual thought and the discussion of these thought in the group. According to Davis (2003) this learning environment supported learners' planning and evaluation skills. We also found a development in these two skills as well. The last question in the manual asked for the evaluation of the course by concept map or diagram. PSTs draw their concept maps or diagram to show their evaluation. Some of the PSTs preferred to draw figures to show this development as well and PSTs stated in their interview that their models for evaluation were getting better. They told that when they compared their first model and last model, they saw an improvement.

In conclusion, it was observed that metacognitive prompts inserted into the manual contributed to the PSTs' metacognitive development. PSTs reported in the interviews that, at the beginning of the course they had difficulty in answering the questions in the manual. These questions were metacognitive prompts which asked them to monitor their learning, to evaluate their learning and their reasoning for conditional knowledge. Besides this, there were also prompts for procedural knowledge and declarative knowledge but these questions did not force them very much at the lesson. From the pre interview, it was found that they have already used declarative and procedural knowledge. However, they had had difficulty in conditional knowledge, planning, monitoring and evaluation skills. It was obvious from the results that this course helped

them develop conditional knowledge and metacognitive skills. Lin and Lehman (1998) designed a computer based laboratory course and used prompts to help pre-service teachers communicate their knowledge, results and discuss their explanations and reasons. They found that the group which was provided metacognitive prompts outperformed the control group. Another example for the study with metacognitive prompts is the study of Schwartz et al. (2009). They designed software which was a teachable agent. This agent used metacognitive prompts during the learning. According to Schwartz et al, normally students neither check their learning nor monitor their progressing. However, when they use this software, students regulate their learning by monitoring and evaluating the agent's learning.

There was an interesting result obtained from the study. It was expected that Selin and Ada outperformed other PSTs in terms of metacognitive development as these cases have more learning strategies when compared with other PSTs. However it was found that PSTs who had less learning strategies caught up with the Selin and Ada in terns of metacognitive development and their frequencies of metacognitive knowledge and skills were developed as much as Selin and Ada. Even, some of them reported more metacognitive knowledge and skills than Selin and Ada. The reason for this result may be that PSTs who had less learning strategies may be aware of their learning strategies and they found opportunity in the course to apply these strategies. The second reason could be that they may develop their learning strategies during the course. According to the quantitative results, a significant increase was found in the score of cognitive strategies sub scale. Cognitive strategies referred to the strategies learners had. This result also supported the second reasoning for this surprising result. However detailed further study is needed to understand the reasons better.

5.1.3 Learning Environment of the Laboratory Course with Metacognitive Prompts

To be able to investigate the learning environment in terms of metacognition, metacognitive orientation scale (MOLES-S) of Thomas (2002) was used. According to Thomas (2002) the indicators of metacognitively learning environment are summarized as metacognitive demands, student-student discourse, student-teacher discourse, student voice, distributed contribution, teacher encouragement and emotional support. It was found that except for student-teacher discourse, an increase in these indicators was observed. Besides, PSTs' interviews included these evidences as well. The decrease in student teacher discourse may be a result for inquiry based lesson. The course was designed as inquiry based to support PSTs' metacognition. It was known that inquiry based lessons support student-student discourse more than student-teacher discourse (Hofstein, Navon, Kipnis & Mamlok- Naaman, 2005). In addition, significant increase in student voice supported that inquiry based environment was provided in this course. This study also supported that inquiry based lesson with metacognitive prompts is appropriate to support the development of metacognition in the laboratory course. This result is consistent with the study of Kipnis and Hofstein (2007) who suggested that inquiry based laboratory course provided learners an environment that the learners' had the opportunity to use their metacognition and thanks to the help of inquiry based activities they could develop their metacognition as well. Differently from the study of Kipnis and Hofstein (2007) this study included metacognitive prompts to help student be aware of their metacognition. Besides, these prompts helped them develop their metacognition. It can be concluded that inquiry based laboratory course and metacognitive prompts together supported PSTs' metacognition development.

As a result of this course, PSTs became aware of their own learning and how they were learning and improving their knowledge. Furthermore, they were aware of the different thoughts of their friends while they were discussing their own ideas. This was

also an important point in metacognition that the learner discovered the different ideas of other people.

PSTs' thoughts about the course were also interesting. They were aware of the different features of this course which differentiate the course from other laboratory courses they had. One of the common thoughts is that the explanation of their rating contributed very much to question their knowledge. These explanations helped them be aware of what they knew and how they knew and where they applied this knowledge.

They also indicated in the interview that they were pleased with the individual questions in the manual that helped them be aware of their own thinking. Besides the individual questions, they appreciated the last question which asked the evaluation of the course. According to the PSTs, although they had difficulty in this question, it provided them opportunity with thinking on their learning. One of the PSTs told that she started using this question in her lesson plan as well.

Another striking result was that PSTs reported in the interview that their confidence in science increased with this course. It may be concluded that metacognitive prompts helped them be aware of their strengths and weaknesses in their learning. Besides, these prompts helped them plan, monitor and evaluate their learning as well. While their metacognitive knowledge and skills were developed with the help of prompts, their self confidence in science may be reinforced during this process. The study of Kleitman and Stankov (2007) supported this result that they found a moderate correlation between metacognition and self confidence. However, more research is needed to support this result. This study had not been designed to test this result but from the interviews, this result emerged and a new study can be conducted to test this result.

5.2 Implications and Recommendations for Further Researches

According to the results derived from the study, some implications and recommendations for further research were suggested under this title. What we found in

this current study supported the importance of metacognition in the learning environment. One of the ways to enhance learners' metacognition is using the metacognitive prompts in the course. It was found that the prompts used in this current study worked properly to develop PSTs' metacognitive knowledge and skills. As suggested by Kipnis and Hofstein (2007), inquiry based learning environment was provided to support PSTs' metacognition. This study suggests that this kind of learning environment with supporting learners' metacognition should be used in laboratory course to be able to support learners' construction of knowledge. While they were constructing their knowledge, they should use their metacognition to be aware of what they are thinking. Furthermore, they should plan, monitor and evaluate their learning to be a successful learner. Metacognitive prompts are useful tools to control this learning process. To be able to use these prompts in the classroom, PSTs should know how to use metacognitive prompts. Therefore, this kind of laboratory course provides them with opportunity to understand how to use prompts. Besides metacognition, they should have various learning strategies to be able to help their students. Metacognition enables one to be aware of her/his learning strategies. Therefore, new learning strategies can be searched or they can be aware of the weaknesses and strengths of their existing learning strategies.

In terms of the further researchers, some suggestions were presented as items below.

- This current study is implicitly conducted. An explicit design can be conducted for further research and the results can be compared with this study.
- Before conducting the current research, PSTs' existing learning strategies were investigated and it was observed that PSTs who had various learning strategies had more metacognitive knowledge and skills. A study including both instruction of learning strategies and metacognition can be conducted.

- It was found that PSTs' self confidence in science increased at the end of the lesson. A study looking for the relation between self confidence and metacognition in laboratory course can be conducted to investigate this relation in detailed.
- The qualitative part of this research included only female participants. It was known in the literature that a gender difference was known in metacognition. A detailed study for gender difference in laboratory course can be investigated in the future research.

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APPENDIX A

LABORATORY MANUALS

LAB 5: BLACK BOX

This lab is focused on observations and inferences of basic science process skills.

5.1. Black Box

Preliminary Information

This laboratory experiment will provide you opportunity to understand that scientific knowledge includes observations, inferences and predictions.

Materials

None needed

Procedure

1. Carefully examine the Black Box model demonstrated by the instructor.

2. Make observations and make records of your observations (data)

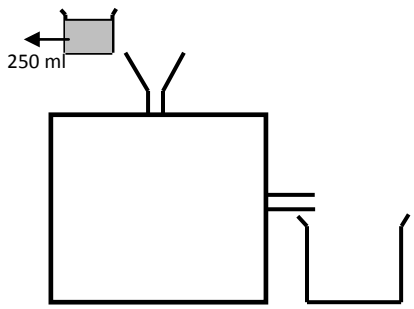


Figure 1

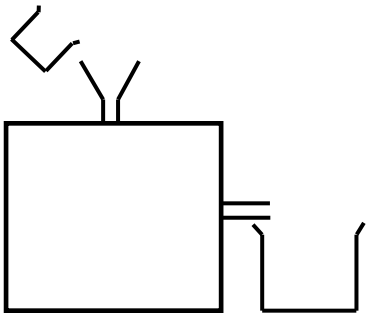


Figure 2

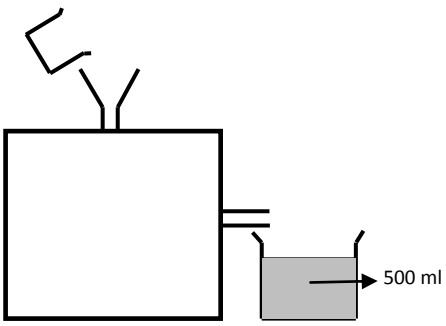


Figure 3

PLEASE RESPOND INDIVIDUALLY

1. Record your observations (data). **(individually)**

2. a. What can you infer based on your observations about the system inside the black box? Please write all plausible inferences you can make. **(individually)**

b. Explain the reasoning underlying your inference. **(individually)**

c. Rate your confidence in your inferences on a 5 point scale from Not At All Confident to Very Confident.

Not at all confident				Very confident
1	2	3	4	5

d. Explain the basis of your confidence rating **(individually)**

3. a. Based on your observations and inferences suggest **your own model** that you think explain step by step how the phenomenon (or demo) works.

- *What experiences gave you ideas to help you make sense of your model?*

- *Where else in your life have you seen models like the one you designed?*

PLEASE RESPOND AS A GROUP

As a group, based on your observations and inferences, decide on your group model to explain step by step how phenomenon (or demo) works.

Gorup observations:

Group inferences:

Group Predictions:

Group Model:

MATERIALS:

PROCEDURE (include your model here with necessary procedure):

Does your groups's model support your group's inference(s)?

To what extent does your group's model support your group's hypothesis?

PLEASE RESPOND INDIVIDUALLY

How certain are you about the accuracy of the model that your group has drawn based on your group's inferences? Explain your reasoning. **(individually)**
Rate your certainty on a scale from 1-5

Not at all certain				Very certain
1	2	3	4	5

Which observations and inferences make your own model strong when you compare it with your group's models? **(individually)**

Which observations and inferences make your own model weak when you compare it with your group's model? **(individually)**

How did you decide which model to design as a group?

Does every member of your group agree on the model? **(individually)**

How did each member of your group contribute to the learning during this lab? **(individually)**

Did any member of your group give you ideas that you did not think of? **(individually)**

What do you conclude about the value of observation and inference in the scientific method? **(individually)**

Although you could not observe what is in the black box, you made inferences and constituted your hypothesis and created your model. Do you think that scientists make some inferences without observations and make explanations that are inferential in nature? Give some examples and support your answer. **(individually)**

Draw a diagram, model or a concept map (it depends on your creativity) which shows what you have done and learned throughout the lesson. **(individually)**

LAB 6: CANDLE

Introduction:

In this lab you will practice science process skills and try to draw evidence-based conclusions and test them.

6.1. Candle

Preliminary Information

This laboratory experiment will provide you opportunity to practice science process skills, draw evidence based conclusions and test your claims.

Materials

Write the materials that you will use in your investigation.

Cake candles in different colors, three kinds of liquids in bottles,…

_____

_____

Procedure

1. You have cake candles in different colors. Have at least 100 mL of each liquid in separate beakers. Put one candle into each liquid (try each color of liquid and each color of candle at least once), and observe what happens.

Write your ***observations*** to the space provided below.

2. What are your ***inferences*** related to your observations? **(INDIVIDUALLY)**

Rate your confidence in your inferences on a 5 point scale from Not At All Confident to Very Confident. **(INDIVIDUALLY)**

Not at all confident				Very confident
1	2	3	4	5

Explain the basis of your confidence rating. **(INDIVIDUALLY)**

3. Choose one of your observations regarding only one color of a candle. Select the option(s) that you think support(s) your explanation about how the phenomenon works.

a. The mass of the candle is larger/smaller with respect to the liquids.

b. The volume of the candle is larger/smaller with respect to the liquids.

c. The temperature of the candle is cooler/warmer with respect to liquids.

d. The temperatures of the liquids are cooler/warmer with respect to the candle.

e. The density of the candle is larger/smaller with respect to the liquids.

f. The densities of the liquids are larger/smaller with respect to the liquids.

g. Other: …….

4. In this step you are expected to design a method to test your inference according to the choice you made in the previous step.

Write your procedure
Record your data

What is your conclusion(s)? **(INDIVIDUALLY)**

Rate the quality of your method on a 5 point scale from poor to excellent

poor
excellent

1 2 3 4 5

Explain the basis of your confidence rating. Did your method work as you had expected? If there were something unexpected, write please and explain what you did to solve this unexpected situation. **(INDIVIDUALLY)**

PLEASE RESPOND AS A GROUP

5. In this step, you are asked to give the (relative) density of the candle. Please design a method to calculate and/or measure the density of the candle you have selected. Do not forget to express the numbers in correct number of significant figures and in correct form of scientific notation when necessary.

Write your procedure

Record your data (to the back of the page

What is your conclusion(s)? (INDIVIDUALLY)

PLEASE RESPOND INDIVIDUALLY

Rate the quality of your method on a 5 point scale from poor to excellent

poor excellent

1 2 3 4 5

Explain the basis of your confidence rating. Did your method work as you had expected? If there were something unexpected, write please and explain what you did to solve this unexpected situation.

Draw a diagram, model or a concept map (it depends on your creativity) which shows what you have done and learned throughout the lesson

Name : Date:
Section:

LAB 7: THEORY & LAW

Introduction:

In this lab you will not only test a couple of theory and laws related to the particle structure of matter but also reconsider your conceptions of theory and law.

PLEASE RESPOND INDIVIDUALLY

Explain your own thoughts on the role of theory in science with your own words. **(INDIVIDUALLY)**

Do you think that we really need theories? **(INDIVIDUALLY)**

Explain your thoughts on the role of law in science with your own words. **(INDIVIDUALLY)**

Do you think that we really need laws? **(INDIVIDUALLY)**

What do you think about the validity and reliability of theories and laws? **(INDIVIDUALLY)**

Rate your trust in theories on 5 point scale. **(INDIVIDUALLY)**

Not at all trust				Very trust
1	2	3	4	5

Explain the basis of your rating.

Rate your trust in laws on 5 point scale. **(INDIVIDUALLY)**

Not at all trust				Very trust
1	2	3	4	5

Explain the basis of your rating.

Is there a difference in your rating between theory and law? If any, why? **(INDIVIDUALLY)**

Problem

Write at least three evidences, which supports the claim that "Matter is made up of particles"? **(individually)**

a)....

b)....

c)....

Design your own experiment to serve as an evidence to your claim. (YOU DO NOT TEST YOUR EXPERIMENT IN THIS STEP)

Materials

Write the materials that you will use in your investigation.

Procedure

What experiences gave you ideas to help you make sense of your experiment design? **(INDIVIDUALLY)**

Ask your group friends what they think on the evidence for particle theory. Is there a differently answers from yours? If any, do you accept as an evience or not, why? **(INDIVIDUALLY)**

GROUP ACTIVITY

Decide on a claim as a group to serve as an evidence for the particle theory. Then design an experiment to test the claim.

Materials

Write the materials that you will use in your investigation.

Procedure

PLEASE RESPOND INDIVIDUALLY

Write your ***observations/ data*** to the space provided below. **(INDIVIDUALLY)**

Write your ***inferences*** related to your observations to the space provided below. **(INDIVIDUALLY)**

Rate your confidence in your individual method to test the claim **(INDIVIDUALLY)**

Not at all confident Very confident

1 2 3 4 5

Rate your confidence in your group method to test the claim **(INDIVIDUALLY)**

Not at all confident Very confident

1 2 3 4 5

Is there a difference in rating? What are your group experiment's strong and weak sides when you compare it with your own model. **(INDIVIDUALLY)**

Problem:

Design an experiment to collect data to serve as an evidence to the law of conservation of mass **(Grup activity)**

Materials

Write the materials that you will use in your investigation.

(Available ones: vinegar, table salt, locked sandwich bag, electronic balance)

Procedure

...

Write your observations/ data to the space provided below. **(INDIVIDUALLY)**

Write your inferences related to your observations to the space provided below. **(INDIVIDUALLY)**

Draw a model that comes to your mind when law and theory is talked **(INDIVIDUALLY)**

Draw a diagram, model or a concept map (it depends on your creativity) which shows what you have done and learned throughout the lesson **(INDIVIDUALLY)**

Name : Date:

Section:

LAB 8: THEORY-LADEN

Introduction:

In this lab you will have the opportunity to understand the theory-laden nature of scientific knowledge. That is, scientists' theoretical and disciplinary commitments influence their work. Meanwhile you will practice necessary basic and integrated science process skills.

Why cannot we call evolution as law? **(Individually)**

How do scientists see evolutionary theory as scientific enterprise even though they do not see that is happening today or happened in the past? **(Individually)**

Scientists give some different reasonings for the diversity of life such as mutation, migration, natural selaction,etc. What could be the reason(s) for these different reasonings? Can you respond to this question in the light of NOS understanding, please provide examples to support your ideas? **(Individually)**

This activity will give you the opportunity to observe differences and similarities in the characteristics of humans and apes. The apes discussed in this activity are the chimpanzee and the gorilla.

National academy of sciences,*Teaching about evolution and the nature of science* (pp.84-86). National Academy press: Washington, DC.

Problem

Find the morphological relationships between gorillas, chimpanzees, and humans.

Working in groups of four "synthesize" strands of DNA according to the following specifications:

(Each different color of paper clip represents one of the four bases of DNA.)

Materials

Four sets of black, white, green, and red paper clips, each set with 35 paper clips.

Black: adenine (A) Green: guanine (G) White: thymine (T) Red: cytosine (C)

Procedure

Each student will synthesize one strand of DNA. Thirty-five paper clips of each color should provide an ample assortment.

Group member 1: Synthesize a strand of DNA that has the following sequence:

A-G-G-C-A-T-A-A-A-C-C-A-A-C-C-G-A-T-T-A

Label this strand "human DNA", this strand represents a small section of the gene that codes for human hemoglobin protein.

Group member 2: Synthesize a strand of DNA that has the following sequence:

A-G-G-C-C-C-C-T-T-C-C-A-A-C-C-G-A-T-T-A

Label this strand "chimpanzee DNA", this strand represents a small section of the gene that codes for human hemoglobin protein.

Group member 3: Synthesize a strand of DNA that has the following sequence:

A-G-G-C-C-C-C-T-T-C-C-A-A-C-C-A-G-G-C-C

Label this strand "gorilla DNA", this strand represents a small section of the gene that codes for human hemoglobin protein.

Group member 4: Synthesize a strand of DNA that has the following sequence:

A-G-G-C-C-G-G-C-T-C-C-A-A-C-C-A-G-G-C-C

Label this strand "common ancestor DNA", this strand represents a small section of the gene that codes for human hemoglobin protein of a common ancestor of the gorilla, chimpanzee, and human.

Your research study should include;

GROUP ACTIVITY

1. State your group purpose

2. State your group hypothesis to explain how these organisms are related? (Three hypothesis or two hypothesis according to your theory)

3. Compare the human DNA to the chimpanzee DNA by matching the strands base by base (paper clip by paper clip). Count the number of bases that are not the same. Record the data in a table. Repeat the steps with the human DNA and the gorilla DNA.

Hybridization data for human DNA

Human DNA compared to:	**Number of matches**	**Unmatched bases**
Chimpanzee DNA		
Gorilla DNA		

How do the gorilla DNA and the chimpanzee DNA compare with the human DNA?

Data for common ancestor DNA

Common ancestor DNA compared to:	**Number of matches**	**Unmatched bases**
Human DNA		
Chimpanzee DNA		
Gorilla DNA		

What do these data suggest about the relationship between humans, gorillas, and chimpanzees?

4. Write your conclusion. Do the data support any of your hypotheses? Why or why not? **(Individually)**

Draw a model or a concept map which shows your understanding of evolution. **(Individually)**

Draw a diagram, model or a concept map (it depends on your creativity) which shows what you have done and learned throughout the lesson. **(Individually)**

Name : Date:

Section:

LAB 9: YOUNG EXPERIMENT

Introduction:

In this lab you will have the opportunity to understand the tentative nature of scientific knowledge. That is, scientific knowledge is never absolute or certain. All kinds of scientific knowledge, including “facts”, “theories” and “laws” are tentative and subject to change.

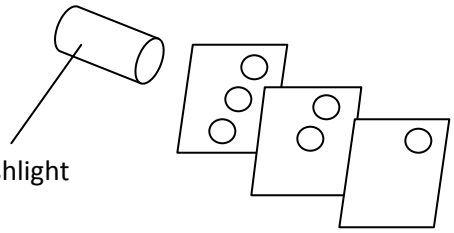
Procedure

1. Use your materials to construct the following experimental set-up into your black box.

Place your cardboards so that the one with three holes will be in the front, the one with two holes will be in the middle, and the one with a hole will be at the back.

There will be 5 cm between cardboards.

The cardboards will be placed so that the holes are in a straight line.



2. Light the flashlight in front of the cardboard with three holes and record your observations. **(INDIVIDUALLY)**

3. What can you infer based on your observations about the light? **(INDIVIDUALLY)**

Rate your confidence in your inferences on a 5 point scale from "Not At All Confident" to "Very Confident". **(INDIVIDUALLY)**

Not at all confident				Very confident
1	2	3	4	5

Explain the reason(s) of your confidence rating. **(INDIVIDUALLY)**

4. Based on your observation(s) and inferences suggest a model to explain the structure of light. **(INDIVIDUALLY)**

5. Draw a group model which explains the structure of light. **(GROUP ACTIVITY)**

Rate your group model on a 5 point scale from Not At All Confident to Very Confident. **(INDIVIDUALLY)**

Not at all confident				Very confident
1	2	3	4	5

Explain the basis of your confidence rating. **(INDIVIDUALLY)**

Evidence

An experimental anomaly was the photoelectric effect, by which light striking metal surface ejected electrons from the surface, causing an electric current to flow across an applied voltage.

Review

1. Does this evidence support the light model you draw in the first part of the experiment? Explain why it supports or why it it does not support your model. **(INDIVIDUALLY)**

2. If the evidence does not support your model, modify your group model to include this piece of evidence given above. **(INDIVIDUALLY)**

3. If evey group member aggrees on this evidence does not support your group model, suggest a group model which includes this piece of evidence. **(GROUP ACTIVITY)**

Rate your group model on a 5 point scale from "Not At All Confident" to "Very Confident". **(INDIVIDUALLY)**

Not at all confident				Very confident
1	2	3	4	5

Explain the reason(s) of your confidence rating. **(INDIVIDUALLY)**

Materials

A cardboard with one slit, a cardboard with two slits, a flashlight, and a black box.

Procedure

1. Light your flashlight.
2. Place the cardboard with one slit in front of your flashlight.
3. Draw the pattern you observe on the side of the black box to the space provided below **(INDIVIDUALLY)**.

4. Remove the cardboard with one slit and place the cardboard with two slits in front of your flashlight.

5. Draw the pattern you observe on the side of the black box to the space provided below. **(INDIVIDUALLY)**

6. Do your observations support the light model you draw as agroup? Report if they are consistent with your model, explain why you think they are consistent or not. **If you think they are inconsistent, suggest your model (INDIVIDUALLY).**

7. Ask your group friend, how they response number6 question. Then, decide as a group on whether your observations support your group model. If it does not support, modify your model to include your observations in this experiment **(GROUP ACTIVITY)**

8. What can you infer about the light based on your observations in three experiments? **(Individually)**

9. If your model has been changed, explain why they change? Can you respond to this question in the light of NOS understanding? **(INDIVIDUALLY)**

10. Draw a diagram, model or a concept map (it depends on your creativity) which shows the process have done and learned throughout the lesson **(INDIVIDUALLY)**

Name : Date:

Section:

LAB 10: CREATIVITY IN SCIENCE

Introduction:

In this lab you will have the opportunity to understand the creative and imaginative nature of scientific knowledge. Scientific knowledge is created from human imaginations and logical reasoning. This creation is based on observations and inferences of the natural world.

Preliminary Information

In this lab activity, you will try to discover what a particular instrument is used for. You will perform drive theories about the function of the instrument you are given and perform an experiment to show its functionality.

10.2.1. The instrument

Materials

A box of an instrument.

INDIVIDUALLY

Procedure

5. Open the box to see what type of an instrument you have.

6. Carefully observe the instrument for its parts and draw a figure of the instrument below.

7. What can you infer based on your observations about the function of the instrument? **(INDIVIDUALLY)**

8. Rate your confidence in your inferences on a 5 point scale from "Not At All Confident" to "Very Confident". **(INDIVIDUALLY)**

Not at all confident				Very confident
1	2	3	4	5

Explain the reason(s) of your confidence rating. **(INDIVIDUALLY)**

GROUP ACTIVITY

1. As a group, what can you infer based on your observations about the function of the instrument?

2. Rate your confidence in your group inferences on a 5 point scale from "Not At All Confident" to "Very Confident". **(INDIVIDUALLY)**

Not at all confident				Very confident
1	2	3	4	5

Explain the reason(s) of your confidence rating. **(INDIVIDUALLY)**

10.2.2. Design an experiment

Preliminary Information

Based on your observation and inferences suggest an experiment to show the functionality of the instrument you have.

INDIVIDUALLY

Research question:

Hypothesis:

Variables (& operational definitions):

Materials:

Procedure:

GROUP ACTIVITY

Research question:

Hypothesis:

Variables (& operational definitions):

Materials:

Procedure:

Conclusions:

When do scientists need to use creativity? **(INDIVIDUALLY)**

How is creativity important in science? Can you give an example? **(INDIVIDUALLY)**

How do you need creativity in your daily life? **(INDIVIDUALLY**

Draw a diagram, model or a concept map (it depends on your creativity) which shows the process you have done and learned throughout the lesson **(INDIVIDUALLY)**

APPENDIX B

Pre- Interview Questions

1. yeni bir konuyu öğrenirken nasıl bir düşünme sürecinden geçersin?
2. Fen konularını öğrenirken kendine ne kadar güveniyorsun?
3. Günlük yaşamda bilimsel düşünmeye ihtiyaç duyuyor musun?
4. Bilgileri aklında nasıl organize ediyorsun?
5. Yeni bilgilerle nasıl başa çıkıyorsun?
6. Öğrenme sürecini nasıl kontrol ediyorsun?
7. Öğrenmelerini nasıl değerlendiriyorsun?
8. Öğrenme sürecinde başarısız olduğunda bununla ilgili neler yaparsın?

APPENDIX C

Post- Interview Questions

1. Laboratuar föylerinin içeriği hakkında ne düşünüyorsun? Daha önce bu tarzda bir föyle karşılaştın mı?

2. Laboratuar dersi, daha önce derslerde öğrendiklerine ne yönde katkı sağladı?

3. Şu an Fen konularını öğrenirken kendine ne kadar güveniyorsun?

4. Günlük yaşamda bilimsel düşünmeye ihtiyaç duyuyor musun?

5. Laboratuvar dersi boyunca bilgileri nasıl organize ettin?

6. Laboratuvar dersi boyunca öğrenmelerini nasıl kontrol ettin?

7. Laboratuvar dersi boyunca öğrenmelerini nasıl değerlendirdin?

8. Öğrenme sürecinde başarısız olduğunda bununla ilgili neler yaptın?

APPENDIX D

QUESTIONNAIRES

Self-Assessment Questionnaire

Please indicate your level of agreement with the following statements by marking the appropriate statement that represents you at the right side.	Not at all	Some- what	Moderately so	Very much so
1.I was aware of my own thinking	❑	❑	❑	❑
2. I checked my work while I was doing it.	❑	❑	❑	❑
3. I attempted to discover the main ideas in the test questions	❑	❑	❑	❑
4. I tried to understand the goals of the test questions before I attempted to answer	❑	❑	❑	❑
5. I was aware of which thinking technique or strategy to use and when to use it.	❑	❑	❑	❑
6. I corrected my errors.	❑	❑	❑	❑
7. I asked myself how the test questions related to what I already knew.	❑	❑	❑	❑
8. I tried to determine what the test required.	❑	❑	❑	❑
9. I was aware of the need to plan my course of action.	❑	❑	❑	❑
10. I almost always knew how much of the test I had left to complete.	❑	❑	❑	❑
11. I thought through the meaning of the questions before I began to answer them.	❑	❑	❑	❑
12. I made sure I understood just what had to be done and how to do it.	❑	❑	❑	❑
13. I was aware of my ongoing thinking processes	❑	❑	❑	❑
14. I kept track of my progress and, if necessary, I changed my techniques or strategies.	❑	❑	❑	❑
15. I used multiple thinking techniques or strategies to solve the test questions.	❑	❑	❑	❑
16. I determined how to solve the test questions.	❑	❑	❑	❑
17. I was aware of my trying to understand the test questions before I attempted to solve them.	❑	❑	❑	❑
18. I checked my accuracy as I progressed through the test.	❑	❑	❑	❑
19. I selected and organized relevant information to solve the test questions.	❑	❑	❑	❑
20. I tried to understand the test questions before I attempted to solve them.	❑	❑	❑	❑

Metacognitive Orientation Scale (MOLES-S)

Name _____ Gender (M or F) _____

1. Purpose of the Questionnaire

This questionnaire asks you to describe HOW OFTEN each of the following important practices takes place in this science classroom. There is no right or wrong answers. This is not a test and your answers will not affect your assessment. Your opinion is what is wanted. Your answers will enable us to improve future science classes.

Please indicate your level of agreement with the following statements by marking the appropriate statement that represents you at the right side.	**Almost Always**	**Often**	**Sometimes**	**Seldom**	**Almost Never**
In this science classroom:					
1. Students are asked by the teacher to think about how they learn science	❑	❑	❑	❑	❑
2. Students are asked by the teacher to explain how they solve science problems.	❑	❑	❑	❑	❑
3. Students are asked by the teacher to think about their difficulties in learning science.	❑	❑	❑	❑	❑
4. Students are asked by the teacher to think about how they could become better learners of science.	❑	❑	❑	❑	❑
5. Students are asked by the teacher to try new ways of learning science.	❑	❑	❑	❑	❑
6. Students discuss with each other about how they learn science.	❑	❑	❑	❑	❑
7. Students discuss with each other about how they think when they learn science.	❑	❑	❑	❑	❑
8. Students discuss with each other about different ways of learning science.	❑	❑	❑	❑	❑
9. Students discuss with each other about how well they are learning science.	❑	❑	❑	❑	❑
10. Students discuss with each other about how they can improve their learning about science.	❑	❑	❑	❑	❑
11. Students discuss with the teacher how they learn science.	❑	❑	❑	❑	❑
12. Students discuss with the teacher about how they think when they learn science.	❑	❑	❑	❑	❑
13. Students discuss with the teacher about different ways of learning science.	❑	❑	❑	❑	❑

14. Students discuss with the teacher about how well they are learning science.	❑	❑	❑	❑	❑
15. Students discuss with the teacher about how they can improve their learning of science	❑	❑	❑	❑	❑
16. It is OK for students to tell the teacher when they don't understand science.	❑	❑	❑	❑	❑
17. It is OK for students to ask the teacher why they have to do a certain activity.	❑	❑	❑	❑	❑
18. It is OK for students to suggest alternative science learning activities to those proposed by their teacher.	❑	❑	❑	❑	❑
19. It is OK for students to speak out about activities that are confusing	❑	❑	❑	❑	❑
20. It is OK for students to speak out about anything that prevents them from learning	❑	❑	❑	❑	❑
21. Students help the teacher plan what needs to be learned.	❑	❑	❑	❑	❑
22. Students help the teacher decide which activities they do.	❑	❑	❑	❑	❑
23. Students help the teacher to decide which activities are best for them.	❑	❑	❑	❑	❑
24. Students help the teacher decide how much time they spend on activities.	❑	❑	❑	❑	❑
25. Students help decide when it is time to begin a new topic.	❑	❑	❑	❑	❑
26. The teacher encourages students to try to improve how they learn science.	❑	❑	❑	❑	❑
27. The teacher encourages students to try different ways to learn science.	❑	❑	❑	❑	❑
28. The teacher supports students who try to improve their science learning.					
29. The teacher supports students who try new ways of learning science.	❑	❑	❑	❑	❑
30. The teacher encourages students to talk with each other about how they learn science.	❑	❑	❑	❑	❑
31. Students are treated fairly.	❑	❑	❑	❑	❑
32. Students' efforts are valued.	❑	❑	❑	❑	❑
33. Students' ideas are respected.	❑	❑	❑	❑	❑
34. Students' individual differences are respected.	❑	❑	❑	❑	❑
35. Students and the teacher trust each other.	❑	❑	❑	❑	❑

APPENDIX E

PSTs' LEARNING STRATEGIES

Table E.1 learning strategies of Selin

Strategies	Quotation	Metacognitive knowledge and skills	Our interpretation
Rhymes	If there is something very long that I cannot memorize, I can make up some rhymes. I made it in literature for example. I made interesting rigmaroles between the poems and poets. I did not remember them now but during the exam these foolish rhymes turned around my mind and I wrote the answer easily. Ezberleyemeyeceğim kadar uzun şeyler olduğunda tekerlemeler uyduruyorum kendimce. Mesela edebiyat dersinde yapmıştım şey yapmıştım sairlerle şiirleri arasında ilginç sacma bir tekerleme yapmıştım. Su an ne olduğunu hatırlamıyorum ama sınavdayken o tekerleme kafamda döner dururdu ve ben tak tak cevaplardım soruları.	Declarative knowledge	The PST knows the rhymes strategy but she does not report when , where and why to use this strategy. Not remembering the rhymes she had made up is supporting that she does not know how effectively use it.
Organizing	When somebody asks me a question for example related to force. I organize the knowledge by questions and answers, like what is force, what does it depends on. Mesela birisi bana kuvvetle ilgili bir soru soruyor diyelim. Ben bilgileri soru ve cevap seklinde organize ediyorum. Mesela kuvvet nedir nelere bağlıdır falan.	Procedural knowledge	She knows how to organize the knowledge.

Table E.1 (continued)

Self-questioning	When I tell something to myself, I'm aware of the sentences. Then I wonder why it is in this way, why it is like this? Then I search. When I tell the topic myself, I notice what I do not understand and I turn back and look again. Kendi kendime bir şeyler anlattığımda, kurduğum cümlenin farkına varıyorum. Sonra Bu neden böyle, neden bu şekilde diye merak ediyorum ve araştırıyorum. Bir konuyu kendi kendime anlattığımda neleri anlamadığımı fark ediyorum ve geriye donup tekrar bakıyorum.	Conditional knowledge & Evaluation	She knows how to control her learning She notices when she does not understand something and turn back which shows that she is evaluating her learning.
Rewriting	For example, learning theories is our new homework. I hate memorizing, at least the social subjects. There were summaries, I read them. Then I looked some theorists like Piaget. I wrote who is Piaget then some steps were arisen. Then I returned back and wrote them again and revise them. Mesela öğrenme stratejileri yeni ödevimizdi. Ben ezberlemekten nefret ederim en azından sosyal konuları. Neyse orda özetler vardı onları okudum sonra bazı yazarlara baktım Piaget gibi. Sonra Piaget kim oturdum onu yazdım sonra step step ne yazmam gerekenler cıktı. Ondan sonra geriye dondum hepsini yazdım bir de gözden geçirdim.	Procedural knowledge	She is aware of that she does not like memorizing and as a strategy she use rewriting method and told how to use it
Skimming	For example if it is biology, organizing knowledge is difficult. For example a new chapter takes a lot of time and besides, since it is in English, perceiving them in your mind takes long time. Therefore, I start with the summaries which are at the end of the chapter. Some words were written in bold there; I look the definition of these terms. Then a picture can take my interest and I read the under the picture. Then I	Conditional knowledge	She emphasized when and why to use skimming strategy

Table E.1 (continued)

	have general knowledge for the related subject. Mesela biyolojiyse bilgileri organize etmek çok zor oluyor. Mesela bir chapter çok fazla zamanımı alıyor bir de İngilizce olduğundan onu anlamak çok zaman alıyor. O yüzden kitabin sonundaki özetleri okumakla başlıyorum. Bazı kelimeler koyu yazılıyor bu terimlerin anlamlarına bakıyorum. Sonra bakıyorum burada bir resim figür varmış dikkatimi çekiyor onun altında yazılanları okuyorum. Sonra konuyla ilgili genel bir bilgim olmuş oluyor.		
Repeating to someone	For example, when ı return to the dormitory, I tell the subject to my roommate. When I told my friends, I remember it 90% and it is difficult to forget. Ya mesela yurda döndüğümde konuyu oda arkadaşıma anlatıyorum. Birine bir şey anlattığımda o anlattığımın yüzde doksanını hatırlıyorum unutması zor oluyor onları.	Declarative knowledge	She repeats her friend what she learnt at the lesson.

Table E.2 Learning strategies of Deniz

Strategies	Quotation	Metacognitive knowledge and skills	Our interpretation
Rewriting	When I study via writing, keeping something in my mind is easier. .. Yazarak çalıştığımda kafamda bir şeyleri tutmak daha kolay oluyor. When I write keywords and inferences, keeping something in my mind is easier. Anahtar kelimeleri ve çıkarımları yazdığımda onları aklımda tutmak daha kolay oluyor.	Declarative knowledge	This is the knowledge about herself as a learner that she understands best when she writes keywords and inferences.
Analogy	I'm linking the topic with something in daily life…For example; linking the function of organelles with people working in a factory who are producing, delivering, digesting… Öğrendiğim konuyu günlük hayattan bir şeylerle bağlıyorum.. Mesela organllerin görevini şeye benzetiyorum fabrikada çalışanlara. İste, üretici dağıtıcı sindirici gibi.	Procedural knowledge	She knows how to linking the function of organelles with people working in a factory
Motivating herself	When I tell myself that I wont not understand anything from this topic, I will be prejudiced and then I really do not understand but when I tell myself I can do this, everything is getting better. Kendi kendime bu konudan hiç bir şey anlayamam dediğim zaman o konuya on yargılı olabiliyorum ve gerçekten de hiç bir şey anlamıyorum. Ama kendi kendime ben bu konuyu anlarım hallederim dediğim zaman her şey yoluna girmeye başlıyor hocam.	Procedural knowledge	She knows how to motivate herself

Table E.3 Learning srategies of Ela

Strategies	Quotation	Metacognitive knowledge and skills	Our interpretation
Rewriting & Underlining	If it is a social science topic Im underlining which seem important and then I write them as items Sosyal bilimlerle ilgili bir konuysa bana önemli görünen şeylerin altını çizerim ve sonra onları maddeler halinde yazarım.	Procedural Knowledge	She told how to use this strategy.
Skimming	If it is biology, I look at the figures which summarize the topic. Eger konu biyolojiyse konuyu ozetleyen figurlere bakarim.	Procedural Knowledge	She told how she applied this strategy.
Forming a phrase	One of my friend did not understand something in organic chemistry. There were numbers you know; one is mono three is tre. She did not understand 5 is penta. I made a weird linking to teach her. Penta was reminding me penti which was a sock brand. We wear sock to our foot and it has five fingers. Five penta. Organik kimyada bir arkadaşım anlatıyordum anlamamıştı. Organik kimyada şey oldu rakamlara takıldı işte monoydu tre. pentaya geldik işte 5 bunu anlatmaya çalışıyorum çok abuk sabuk bir bağlantı kurdum o zamanlar yapıyordum kendi kendime. Bunu anlattığım için bu kaldı aklımda. penta, penti işte ne çorap markası işte nereye giyilir ayağa, ayakta kaç parmak var 5. 5 penta.	Procedural Knowledge	She told how she applied this strategy.

Table E.4 Learning strategies of Didem

Strategies	Quotation	Metacognitive knowledge and skills	Our interpretation
Repeating by herself	for example we are doing something in the labs and we will have a exam… When I go to home, I'm thinking about what we did that day, how we calculate to not to forget. Mesela laboratuarda bir şeyler yapıyoruz ve bunlardan sınav olacağız. Eve gittiğim zaman unutmamak için, o gün ne yaptık onu düşünüyorum iste nasıl hesapladık falan diye.	Procedural Knowledge	She explained how she repeats what she learnt.

Table E.5 Learning strategies of Ada

Strategies	Quotation	Metacognitive knowledge and skills	Our interpretation
mental image	I may not understand a topic sufficiently via reading but learning this via a video or a visual schema is much easier for me and it would be more permanent knowledge. Listeing the topic from a lecturer or an expert is not sufficient for me, I should see the process. Visual images are important for me. Okuyarak bir konuyu yeteri kadar anlayamayabiliyorum ama bunu bir video ile ya da görsel bir sema ile anlamak benim için daha kolay ve kalıcı bilgi oluyor benim için. Bir konuyu hocadan ya da uzman birinden dinlemek benim için yeterli olmuyor. Prosesi de görmem gerekiyor. Görseller benim için çok önemli.	Conditional Knowledge	She explains why using mental image is a useful tool for her.

Table E.5 (continued)

Rewriting	I may write what I see in the book while studying Çalışırken kitapta ne görüyorsam onu yazabiliyorum.	Declarative Knowledge	She is aware of her strategies.
Paraphrasing	I can read then make inference and write my own thoughts. I can write my own evaluations which are useful for me. Okuyabilirim sonra çıkarımlar yapabilirim ve kendi düşüncelerimi yazarım. Bana faydalı olabilecek kendi değerlendirmelerimi yazarım.	Procedural Knowledge	She explains how to use paraphrasing strtaegy.
Linking topics with examples	Instead of reading a topic directly to study, I prefer linking the topics with something, like examples**.** Bir konuyu direk okuyup calismak yerine, o konuyu orneklere yada baska bir seylerle baglantilar kurarak calismayi tercih ediyorum.	Procedural Knowledge	She told how to link topics
Self-questioning	When I start a new topic, I'm questioning how much I connect this topic with my old learning. The thing I should learn is so much and for example I learn ¼ percent and I'm asking myself whether I can make a connection between the rest and the ¼ percent I have learnt and I'm questioning how much I can apply my learning sometimes. Yeni bir konuya geçtiğim zaman ne kadar bağlantı kuruyorum geçmişte öğrendiklerimle, bunu sorgulayabiliyorum. Benim öğrenmem gereken yol uzun ve ben işte 4te 1ini kat ettim ama geri kalan yolla geçmişte kalan arasında bağlantı kurabiliyor muyum ya da ne kadarını hatırlıyorum öğrendiklerimin ne kadarını uyguluyorum bunları sorabiliyorum kendime zaman zaman.	Monitoring	While she was questioning herself about learning, she also monitored her learning.
Motivational strategy	But sometimes I say;I can do this, I belive in myself and I will do better and I will not give up, will go on.	Procedural Knowledge	She knows how to motivate herself

Table E.5 (continued)

	Bazen ben yapabilirim ben inanıyorum kendime diyip daha iyisini yapıp vazgeçmeyeceğim devam edeceğim diyebiliyorum.		

Table E.6 Learning strategies of Gamze

Strategies	**Quotation**	**Metacognitive component**	**Our interpretation**
Mental image	For example, I do not write the part of the cell. I write it as a schema. I mean, the figures are important for me. Maybe I have many figures in my store of knowledge. Mesela hücrenin bölümlerini direk yazmam da, onu şema halinde yazıyorum yani şekil benim için çok önemli. Bilgi dağarcığımda daha fazla sekil bulunuyor galiba.	Declarative Knowledge	She has an idea for herself that she has many figures in her store of knowledge

Table E.7 Learning strategies of Buse

Strategies	Quotation	Metacognitive knowledge and skills	Our interpretation
Self-Questioning strategy	I learn by asking a lot of questions, I have this learning style. I have lots of questions. I do not think that these questions are difficult, easy, logical or illogical. Maybe I'm too boring by asking many questions but I think sometimes I'm asking good questions. If I have questions related to the new topic that I could not answer by myself, I can not learn that topic. First of all, all the questions I have should be answered. Bir de çok soru sorarak öğreniyorum ben öyle bir tarzım da var. Çok fazla sorum oluyor. Hiç bir zaman basit soru zor soru mantıklı mantıksız soru diye bir şey düşünmüyorum. Gerçi çok sıkıcı olabiliyorum çok fazla soru sorarak ama. Bazen de güzel sorular sorduğumu düşünüyorum. Aklımda en ufak bir yeni öğrendiğim bilgiyle ilgi soru işareti varsa öğrenemiyorum. Bir kere soru işaretlerinin hepsinin gitmesi lazım. I think, my memory is working sophisticatedly. For example, I'm learning a new thing which is not related to any other my learning. Understanding this knowledge is much difficult than understanding things which are related with my exist knowledge. But I'm forcing my mind and making inference personally. I try to make a causal relationship. What is it or what is it not, why is it in this way. When I force myself with these questions, I understand better. But sometimes I can stuck in somewhere. If I do not stuck in somewhere and go on my way, I think that I can make my mind work sophisticatedly. For example, instead of saying yes to a situation, thinking on the reasons, causes and thinking on many sides is a sort of example to my memory is working sophisticatedly. Zihnimin çok yönlü çalışıyor diye düşünüyorum. Mesela yeni bir şey öğreniyorum ama öyle bir şey ki daha önceki bilgilerimle hiçbir bağlantısı yok. Onu anlamak bağlantılı şeyleri anlamaktan çok daha zor oluyor. Ama biraz zihnimi zorluyorum kendimce	Procedural Knowledge	She questioned herself and explained how to use this strategy with examples.

Table E.7 (continued)

	çıkarımlar yapıyorum. İşte dediğim gibi neden sonuç ilişkisi kurmaya çalışıyorum. Ne nedir ne değildir neden böyledir. Bunu biraz daha zorladığımda çok daha kalıcı oluyor ve çok daha iyi anlıyorum. Ama bazen bir yerde tıkanmak vardır ya. Tıkanmayıp devam edebiliyorsam zihnimi çok yönlü çalıştırabildiğimi düşünüyorum. Mesela sebebi sonucu nasıl olduğu neden böyle olduğu yani böyle olaya sadece evet oluyor seklinde değil de hani bir sürü yönünü düşünerek bakmak zihnimi çok yönlü çalıştırmak diye düşünüyorum.		
Mental image	Generally, I hate memorizing and Im really enthusiastic about learning something. What Im learning is should be observable, tangible. For example in relativity topic, I said the leacturer that show me something observable or tangible which make it permanent for me... An application which is even very simple or a video can be permanent for me. For example, I dont have chance to apply something but when I watch a video related to it, it becomes permanent for me. Ben genel anlamda ezberden nefret ediyorum ve bir şeyler öğrenmek konusunda gerçekten çok istekliyim ama nasıl öğrenmek, etkilerini görmem lazım öğrendiğim şeyin elle tutulur gözle görülür olması lazım... Bir uygulama pratik çok basit olsa bile aslında bir video ile bile bende kalıcı oluyor mesela pratik yapma şansım yok ama o konuyla yapılmış pratik bir şey izlediğimde o bende çok daha kalıcı olabiliyor.	Procedural Knowledge	She explained how knowledge is permanent for her
Motivating herself	First of all, I never approach a subject with a prejudicious manner. I said myself my mind is working, I love examining something.... therefore, I'm learning easily and obviously, I feel confident in science subjects. Bir kere ön yargılı yaklaşmam kesinlikle hiç bir konuya. Bir şey başlar, ya diyorum ki sonuçta kafam çalışıyor seviyorum sevdiğim bir şey irdelemeyi seviyorum... Bu nedenle kolayca öğrenebiliyorum her şeyi ve açıkçası fen konularında kendime güveniyorum.	Procedural Knowledge	She knows how to motivate herself

APPENDIX F

PSTs' Metacognitive Knowledge and Skills Revealed from Pre Interview

Table F.1 Metacognitive knowledge and skills revealed from Selin case in pre-interview

		Quatations in pre-interview
Metacognitive knowledge	**Declarative knowledge**	• If there is something very long that I cannot memorize, I can make up some rhymes. I made it in literature for example. I made interesting rigmaroles between the poems and poets. I did not remember them now but during the exam these foolish rhymes turned around my mind and I wrote the answer easily. Ezberleyemeyeceğim kadar uzun şeyler olduğunda tekerlemeler uyduruyorum kendimce. Mesela edebiyat dersinde yapmıştım şey yapmıştım sairlerle şiirleri arasında ilginç saçma bir tekerleme yapmıştım. Su an ne olduğunu hatırlamıyorum ama sınavdayken o tekerleme kafamda döner dururdu ve ben tak tak cevaplardım soruları. • For example, when ı return to the dormitory, I tell the subject to my roommate. When I told my friends, I remember it 90% and it is difficult to forget. Ya mesela yurda döndüğümde konuyu oda arkadaşıma anlatıyorum. Birine bir şey anlattığımda o anlattığımın yüzde doksanını hatırlıyorum unutması zor oluyor onları. • For example if it is based on physics, I understand the topic by solving various problems. Mesela bir şey fiziğe dayalıysa onu daha çok problem çözerek anlıyorum.
	Procedural knowledge	• When somebody asks me a question for example related to force. I organize the knowledge by questions and answers, like what is force, what does it depends on. Mesela birisi bana kuvvetle ilgili bir soru soruyor diyelim. Ben bilgileri soru ve cevap seklinde organize ediyorum. Mesela kuvvet nedir nelere bağlıdır falan. • For example, learning theories is our new homework. I hate memorizing, at least the social subjects. There were summaries, I read them. Then I looked some authorities like Piaget. I wrote who is Piaget then some

Table F.1 (continued)

		steps were arisen. Then I returned back and wrote them again and revise them. Mesela öğrenme stratejileri yeni ödevimizdi. Ben ezberlemekten nefret ederim en azından sosyal konuları. Neyse orda özetler vardı onları okudum sonra bazı yazarlara baktım Piaget gibi. Sonra Piaget kim oturdum onu yazdım sonra step step ne yazmam gerekenler çıktı. Ondan sonra geriye dondum hepsini yazdım bir de gözden geçirdim.
	Conditional knowledge	• When I tell something to myself, I'm aware of the sentences. Why is it in this way, why is it like this? Then I search. Kendi kendime bir şeyler anlattığımda, kurduğum cümlenin farkına varıyorum. Sonra Bu neden böyle, neden bu şekilde diye merak ediyorum ve araştırıyorum. Bir konuyu kendi kendime anlattığımda neleri anlamadığımı fark ediyorum ve geriye donup tekrar bakıyorum. • For example if it is biology, organizing knowledge is difficult. For example a new chapter takes a lot of time and besides, since it is in English, perceiving them in your mind takes long time. Therfore, I start with the summaries which are at the end of the chapter. Some words were written in bold there; I look the definition of these terms. Then a picture can take my interest and I read the under the picture. Then I have knowledge for the related subject. Mesela biyolojiyse bilgileri organize etmek çok zor oluyor. Mesela bir chapter çok fazla zamanımı alıyor bir de İngilizce olduğundan onu anlamak çok zaman alıyor. O yüzden kitabin sonundaki özetleri okumakla başlıyorum. Bazı kelimeler koyu yazılıyor bu terimlerin anlamlarına bakıyorum. Sonra bakıyorum burada bir resim figür varmış dikkatimi çekiyor onun altında yazılanları okuyorum. Sonra konuyla ilgili genel bir bilgim olmuş oluyor. • If I can go to lesson, I prefer listening the course from the lecturer because there can be a paragraph in the book which is not clear to understand. I have only the course book to study and they are generally in English and Im not an expert in the topic and I do not have other book to support my learning. But when I ask the lecturer what I do not understand, s/he can explain and give examples. Therefore, listening the topic from the lecturer is a good way for learning

Table F.1 (continued)

		Eğer derse gidebiliyorsam hocadan dinlemeyi tercih ediyorum. Çünkü bazen kitapta bir paragraf oluyor çok net olmuyor anlayamıyorum. Zaten elimde ders kitabi dışında bir kitabımda olmuyor genelde, kitaplarımızda genelde İngilizce. Bir de o konuda uzman ya da araştırma görevlisi de olmadığım için o konuyu destekleyebileceğim kitaplar olmuyor. Ama hocaya sorduğumda o bunu açıklayabiliyor ya da örnekler veriyor. O yüzden konuyu hocadan dinlemek iyi bir öğrenme yolu.
Metacognitive skills	**Planning**	
	Monitoring	• When I stuck in somewhere in a topic, I understand that I have forgotten the previous things in the book or notebook. Then I instantly return and skim my notebook and then I remember and go on learning the topic. Bir konuda bir yerlere takıldıysam kitaptaki ya da not defterimdeki daha önceki şeyleri unutmuşum demektir. Sonra hemen not defterimi acarım bir göz gezdiririm sonra hatırlarım ve konuya kaldığım yerden öğrenmeye devam ederim. • Im reading "The Book of General Ignorance". There was a question that if there is a relation between the influenza virus and cold. Im a scout and I was told that if one has flue, and if s/he comes comping, s/he will get over the flue. I thought for the first time that the camp would be colder how I would get over it, I would be worse. But I went to the camp and as I had been told I got over the flue. Then I read in the book that the reason for the spreading of influenze virus is the crowded place. People get closed each other in cold days and fresh air is decreased in these palces and the influence viruses reproduce. This virus needs a hot place to reproduce but in cold places just like mauntains, they can not live. Then I said "aha, I get flue not because of the cold weather." I got an experience that I got flue before going to the camp and I healed up during the camp. It is very interesting. Although we were cold, we were getting better. Then you understand in that time that you understand the reason. I mean Im learning easily when I link my learning with daily life experience. Mesela bir kitap okuyorum bilimsel cahillikler kitabı diye mesela şey diyor soğuk algınlığı ile grip virüsünün bir alakası var mı diye bir soru var. Bende izciyim. Bize hep şey derlerdi ilk gittiğimizde kampa gelin iyileşirsiniz grip oluyorduk. Diyorduk ki kamp zaten soğuk orda iyice üşüyeceğiz daha faza grip olacağız niye gidelim nasıl iyileşiyorsun ama gidiyorduk ve gerçekten de iyileşiyorduk. Ondan sonra kitapta okudum sebebini grip virüsünün

Table F.1 (continued)

		kısın yayılmasının tek sebebi insanların kalabalık ortamlarda bir arada bulunması acık hava yok ya. Bu yüzden daha kolay ürüyorlarmış. Üremeleri içinde sıcak bir ortama ihtiyaçları varmış hani dağ tas gibi soğuk ortamlarda zaten oluyormuş grip virüsleri barınamıyormuş. haa dedim mesela ondan sonra orda anladım anladığımı mesela. Ha onların bir alakası yokmuş evet bakbende söyle söyle bir deneyim geçirdim kampa gidiyoruz iyileşiyoruz çok ilginç yani üşümemize rağmen falan diyoruz yani. Mesela anladığını o an anlıyorsun haa demek bunun sebebi buymuş diyorsun yani. Yani günlük hayatla bağdaştırınca daha kolay anlıyorum. haaa söyle söyle bir şey olmuştu haa tamam o zaman doğruymuş evet bu bundanmış dediğim zaman o yerleşiyor yani.
	Evaluation	• When I tell something to myself, I notice what I do not understand and I turn back and look again. Bir konuyu kendi kendime anlattığımda neleri anlamadığımı fark ediyorum ve geriye donup tekrar bakıyorum.

Table F.2 Metacognitive knowledge and skills revealed from Deniz case in pre-interview

		Quatations in pre-interview
Metacognitive Knowledge	**Declarative knowledge**	• When I study via writing, keeping something in my mind is easier. When I write keywords and inferences, keeping something in my mind is easier. Yazarak çalıştığım şeyleri aklımda daha iyi tutuyorum. Anahtar kelimeleri ve çıkarımları yazarak çalıştığımda bir şeyleri aklımda tutmak benim için kolaylaşıyor. • I do not think scientifically. I mean I do not question very much. Ya, ben bilimsel düşünmüyorum hocam yani öyle çok sorgulama falan yapmıyorum.
	Procedural knowledge	• I'm linking the topic with something in daily life…For example; linking the function of organelles with people working in a factory who are producing, delivering, digesting, etc. Konuları günlük hayatla bağdaştırmaya çalışıyorum… Mesela, organellerin görevlerini bir fabrikada çalışan insanlara benzetiyorum. İste bu insanlar da üretim yapar, dağıtım yapar, sindirmede görevlidir gibi. • When I tell myself that I do not understand anything from this topic, I will be prejudiced and then I really do not understand but when I tell myself I can do this, everything is getting better.
	Conditional knowledge	• If something is very complex for me, you know medium of instruction is english here, Im looking for the Turkish meaning to understand why Im not understanding the topic. Eğer benim için çok kompleks şeyler varsa, bir de biliyorsunuz hocam burada tüm derslerimiz İngilizce. O yüzden konuyu neden anlamadığımı görebilmek için Türkçe anlamlarına bakarım.
Metacognitive skills	**Planning**	-
	Monitoring	-
	Evaluation	-

Table F.3 Metacognitive knowledge and skills revealed from Ela case in pre-interview

		Quatations in pre-interview
Metacognitive knowledge	**Declarative knowledge**	• When I was at elementary school I did not like science and I wanted to be lawyer. Then when I passed to high school and when I was at high school, especially I did not like physics and I did not feel confident in physics. Then I came to the university and physics is still a nightmare for me. When I was at high school, I told myself that I was not good at physics, at least I could be good at chemistry and biology and I was good at them until I got biology lessons in the university. Now I do not feel confident in biology. I only feel confident in chemistry now. Ben ilkokuldayken fen derslerini sevmezdim hep böyle hukukçu olacağımı söylerdim liseye geçtik lisede de aynı fizikten özellikle hiç hoşlanmazdım fizikte hiç güvenmiyordum kendime. üniversite hayatına geldim hala fizik benim icin hep kabus olmustu. fizik haricinde kimya iste alanıda fen secince lisede bari fizigi yapamıyorum kimya ve biyolojiyi daha iyi anlamaya calısayım daha iyi yapayım onlar güzeldi taki bu okulda biyoloji derslerini alana kadar biyoloji de oyle koptu. simdi kimya ile gidiyorum ben. bir tek kimyada guveniyorum digerlerinde guvenmiyorum.
	Procedural Knowledge	• If it is a social topic Im underlining which seem important and then I write them as items. Sosyal bilimlerle ilgili bir konuysa bana önemli görünen şeylerin altını çizerim ve sonra onları maddeler halinde yazarım. • If it is biology, I look at the figures which summarize the topic. Eğer konu biyolojiyse konuyu özetleyen figürlere bakarım. • One of my friend did not understand something in organic chemistry. There were numbers you know; one is mono three is tre. She did not understand 5 is penta. I made a weird linking. Penta was reminding me penti which was a sock brand. We wear sock to our foot and it has five fingers. Five penta. Organik kimyada bir arkadaşım anlatıyordum anlamamıştı. Organik kimyada şey oldu rakamlara takıldı işte monoydu tre. pentaya geldik işte 5 bunu anlatmaya çalışıyorum çok abuk sabuk bir bağlantı kurdum o zamanlar yapıyordum kendi kendime. Bunu anlattığım için bu kaldı aklımda. penta, penti işte ne çorap markası işte nereye giyilir ayağa, ayakta kaç parmak var 5. 5 penta.

Table F.4**:** Metacognitive knowledge and skills revealed from Didem case in pre-interview

Metacognitive knowledge		**Quatations in pre-interview**
Metacognitive knowledge	**Declarative knowledge**	• I do not have a problem in biology and chemistry but sometimes I have problem in physics that I do not understand something. But generally I feel confident in science. Biyoloji ve kimyada sorun yasamıyorum pek ama bazen fizikte anlamadığım yerler oluyor. Ama genel anlamda fende kendime güveniyorum.
	Procedural Knowledge	• For example we are doing something in the labs and we will have a exam… When I go to home, I'm thinking about what we did that day, how we colculate to not to forget. Mesela laboratuarda bir şeyler yapıyoruz ve bunlardan sınav olacağız. Eve gittiğim zaman unutmamak için, o gün ne yaptık onu düşünüyorum iste nasıl hesapladık falan diye.
	Conditional Knowledge	• While the lecturer is telling the topic, if s/he indicates a part as an important section for the exam, I won't forget these parts and they become important for me. I do not care the rest parts which are not showed as important by the lectrurer. Mesela derste hoca bir şey anlatıyor bu sınavda çıkar dediği anda o benim için önemli bilgi kategorisine giriyor ve onu unutmuyorum ama diğerlerini o kadar önemsemiyorum hani sınav zamanına kadar pek ilgilenmediğim şeyler oluyor. Hocanın eğer sınavda çıkacak dediği şeyler hep aklımda kalıyor.
Metacognitive Skills	**Planning**	
	Monitoring	
	Evaluation	

Table F.5**:** Metacognitive knowledge and skills revealed from Ada case in pre-interview

Metacognitive knowledge		Quatations in pre-interview
Metacognitive knowledge	**Declarative knowledge**	• I may write what I see while studying. Çalışırken kitapta ne görüyorsam onu yazabiliyorum • While I was dealing with science, to be able to have a control over a topic, I should be curious about this topic. If I do not have an interest over a topic, I can not study on it and I can not feel qualified about it. Bilimle uğraştığımda o konuya çok iyi hakim olmam için önce merak duymam gerekiyor. Eğer hiç ilgimi çekmeyen bir konuysa üzerine çalışamam ve hiç bir şekilde kendimi yeterli hissedemem. • Even the studying time in a day can affect my perception about the topic. Gün içinde çalıştığım saatler bile benim algılamamı etkiliyor olabilir. • My reactions to failure are not parallel. Either I get upset too much and I gıve up or I may try my best to learn with a big ambitious. Two situations may accour, either too good or too bad. Başarısızlığa karsı tepkilerim böyle çok paralel gitmez ya çok üzülürüm bırakabilirim ya da tam tersi çok büyük bir hırsla en iyi şekilde onu öğrenmeye başlarım ya da bilmiyorum işte o anki psikolojimle çok orantılı. İkisi de olabilir ya çok iyi ya çok kötü.
	Procedural Knowledge	• I can read then make inference and write my own thoughts. I can write my own evaluations which is useful for me. Okuyabilirim sonra çıkarımlar yapabilirim ve kendi düşüncelerimi yazarım. Bana faydalı olabilecek kendi değerlendirmelerimi yazarım.

Table F.5 (continued)

		• Instead of studying a topic directly, I prefer linking the topics with something, like examples. Bir konuyu direk okuyup çalışmak yerine, o konuyu örneklere ya da başka bir şeylerle bağlantılar kurarak çalışmayı tercih ediyorum. • But sometimes I say myself, I can do this, I belive in myself and I will do better and I will not give up, will go on. Bazen ben yapabilirim ben inanıyorum kendime diyip daha iyisini yapıp vazgeçmeyeceğim devam edeceğim diyebiliyorum.
	Conditional Knowledge	• I may not understand a topic sufficiently via reading but learning this via a video or a visual schema is much easier for me and it would be more permanent knowledge. Listeing the topic from a lecturer or an expert is not sufficient for me, I should see the process. Visual images are important for me. Okuyarak bir konuyu yeteri kadar anlayamayabiliyorum ama bunu bir video ile ya da görsel bir sema ile anlamak benim için daha kolay ve kalıcı bilgi oluyor benim için. Bir konuyu hocadan ya da uzman birinden dinlemek benim için yeterli olmuyor. Prosesi de görmem gerekiyor. Görseller benim için çok önemli.
Metacognitive Skills	**Planning**	• Im deciding on the method that I will study with. I think on time when I will study. Konuya hangi methodla calisacagima karar veririm. Ne zaman calisacagimi da dusunurum.
	Monitoring	• When I start a new topic, I'm questioning how much I connect this topic with my old learning. The thing I should learn is so much and for example I learn ¼ percent and I'm asking myself whether I can make a connection between the rest and the ¼ percent I have learnt and I'm questioning how much I can apply my learning sometimes. Yeni bir konuya geçtiğim zaman ne kadar bağlantı kuruyorum geçmişte öğrendiklerimle, bunu sorgulayabiliyorum. Benim öğrenmem gereken yol uzun ve ben işte 4te 1ini kat ettim ama geri kalan yolla geçmişte kalan arasında bağlantı kurabiliyor muyum ya da ne kadarını hatırlıyorum öğrendiklerimin ne kadarını uyguluyorum bunları sorabiliyorum kendime bazen.

Table F.6**:** Metacognitive knowledge and skills revealed from Gamze case in pre-interview

Metacognitive knowledge		**Quatations in pre-interview**
Metacognitive knowledge	**Declarative knowledge**	• For example, I do not write the part of the cell. I write it as a schema. I mean, the figures are important for me. Maybe I have many figures in my store of knowledge. Mesela hücrenin bölümlerini direk yazmam da, onu şema halinde yazıyorum yani şekil benim için çok önemli. Bilgi dağarcığımda daha fazla sekil bulunuyor galiba. • I cannot understand science by reading directly, especially in chemistry and biology. Maybe in physics but it is also required experiment. I should make experiments and see something to understand. Direk bir kâğıttan okuyarak ben feni anlayamıyorum özellikle biyolojide ve kimyada. Belki fizikte ama fizikte de deney gerekiyor hani deneylerle kendim gördüğümde daha çok inanıyorum açıkçası.
	Procedural Knowledge	
	Conditional Knowledge	• My mind should be clear because when I think another thing, I cannot get the knowledge in my mind. I have to focus on. To do this, I have to stop everything in my life. Kafam rahat olmalı, başka bir şey düşünmemem gerekir. Çünkü başka bir şey düşündüğüm zaman o bilgi beynime giremez. Kesinlikle odaklanmam lazım. Bunun için ne yapmam gerek işte her şeye galiba diğer hayatımdaki başka şeylere dur demem gerekir.
Metacognitive Skills	**Planning**	
	Monitoring	
	Evaluation	

Table F.7**:** Metacognitive knowledge and skills revealed from Buse case in pre-interview

Metacognitive knowledge		**Quotations in pre-interview**
Metacognitive knowledge	**Declarative knowledge**	• being enthusiastic about learning is very important for me. When I meet new knowledge, I may refuse to learn because may be this is not appropriate for scientific thinking but if I do not want to learn it, if I think it would not useful for me, I cannot learn. Bir kere benim için öğrenmek istemem çok önemli. Yeni bir bilgiyle karsılaştığımda onu öğrenmeyi reddedebiliyorum. Çünkü hani belki bu çok bilimsel düşünmeye uygun olmayacak ama bir bilgiyle karşılaşıyorum eğer onu öğrenmek istemiyorsam, bana faydalı olmadığını düşünüyorsam, öğrenemiyorum. • Sharing my knowledge with someone else and getting feedback, like you are right or you know wrongly, are really important for me. Bilgilerimi başkalarıyla paylaşmak da açıkçası benim için önemli. Birileriyle bildiklerimi paylaşıp dönütler aldıkça, doğru ya da yanlış biliyorsun şöylesin böylesin gibi dönütler almak da benim için çok önemli oluyor
	Procedural Knowledge	• I learn by asking a lot of questions, I have this learning style. I have lots of questions. I do not think that these questions are difficult, easy, logical or illogical. Maybe I'm too boring by asking many questions but I think sometimes I'm asking good questions. If I have questions related to the new topic that I could not answer by myself, I cannot learn that topic. First of all, all the questions I have should be answered. Bir de çok soru sorarak öğreniyorum ben öyle bir tarzım da var. Çok fazla sorum oluyor. Hiç bir zaman basit soru zor soru mantıklı mantıksız soru diye bir şey düşünmüyorum. Gerçi çok sıkıcı olabiliyorum çok fazla soru sorarak ama. Bazen de güzel sorular sorduğumu düşünüyorum. Aklımda en ufak bir yeni öğrendiğim bilgiyle ilgi soru işareti varsa öğrenemiyorum. Bir kere soru işaretlerinin hepsinin gitmesi lazım. • I think my memory is working sophisticatedly. For example, I'm learning a new thing which is not related to any other my learning. Understanding it is much difficult than understanding things which are related with my exist knowledge. But I'm forcing my mind and making inference personally. I try to make a causal relationship. What is it or what is it not, why is it in this way.When I force myself with these

Table F.7 Continued

		questions, I understand better. But sometimes I can stuck in somewhere. If I do not stuck in somewhere and go on my way, I think that I can make my mind work sophisticatedly. For example, instead of saying yes to a situation, thinking on the reasons, causes and thinking on many sides is a sort of example to my memory is working sophisticatedly. Zihnimin çok yönlü çalışıyor diye düşünüyorum. Mesela yeni bir şey öğreniyorum ama öyle bir şey ki daha önceki bilgilerimle hiçbir bağlantısı yok. Onu anlamak bağlantılı şeyleri anlamaktan çok daha zor oluyor. Ama biraz zihnimi zorluyorum kendimce çıkarımlar yapıyorum. İşte dediğim gibi neden sonuç ilişkisi kurmaya çalışıyorum. Ne nedir ne değildir neden böyledir. Bunu biraz daha zorladığımda çok daha kalıcı oluyor ve çok daha iyi anlıyorum. Ama bazen bir yerde tıkanmak vardır ya. Tıkanmayıp devam edebiliyorsam zihnimi çok yönlü çalıştırabildiğimi düşünüyorum. Mesela sebebi sonucu nasıl olduğu neden böyle olduğu yani böyle olaya sadece evet oluyor seklinde degilde hani bir sürü yönünü düşünerek bakmak zihnimi çok yönlü çalıştırmak diye düşünüyorum. • First of all, I never approach a subject with a prejudicious manner. I said myself my mind is working, I love examining something.... therefore, I'm learning easily and obviously, I feel confident in science subjects. Bir kere ön yargılı yaklaşmam kesinlikle hiç bir konuya. Bir şey başlar, ya diyorum ki sonuçta kafam çalışıyor seviyorum sevdiğim bir şey irdelemeyi seviyorum... Bu nedenle kolayca öğrenebiliyorum her şeyi ve açıkçası fen konularında kendime güveniyorum. • Let's think that I have not got a background and I'm learning a new knowledge. The man who brought the knowledge this stage followed a process and I should know the evolution process to understand it. I mean that I cannot take the knowledge in the middle and I should make a connection with something, especially with daily life.

Table F.7 (continued)

		Diyelim ki bir temelim yok yeni bir bilgi öğreniyorum o bilgiyi o aşamaya getiren insan nasıl bir yol izlemişse o zamana kadar onun bir gelişim sürecini bilmem gerekiyor, onu anlamam için. Hani bir bilgiyi böyle tam orta yerinden alıp öğrenemiyorum ve bağlantıda kesin kurmam gerekiyor diğer şeylerle özellikle de günlük yaşamla bağlantı kurmam gerekiyor buna çok ihtiyacım oluyor. • Generally, I hate memorizing and I'm really enthusiastic about learning something. What Im learning is should be observable, tangible. For example in relativity topic, I said the leacturer that show me something observable or tangible which make it permanent for me... An application which is even very simple or a video can be permanent for me. For example, I don't have chance to apply something but when I watch something related to it, it becomes permanent for me Ben genel anlamda ezberden nefret ediyorum ve bir şeyler öğrenmek konusunda gerçekten çok istekliyim ama nasıl öğrenmek, etkilerini görmem lazım öğrendiğim şeyin elle tutulur gözle görülür olması lazım... Bir uygulama pratik çok basit olsa bile aslında bir video ile bile bende kalıcı oluyor mesela pratik yapma şansım yok ama o konuyla yapılmış pratik bir şey izlediğimde o bende çok daha kalıcı olabiliyor. • If I cannot make a connection with my old knowledge, I try to learn the second part and try to make connection between two parts. If there is no connection with my old knowledge, daily life or to be learned things, learning this knowledge is too difficult." Eğer eski bilgilerimle bağlantı kuramıyorsam ya da ondan bir sonra mesela şey de deneyebiliyorum, bir bilgi var bir sonraki aşamayı öğrenmeye çalışıyorum ikisinin birbiriyle bağlantısını kuruyorum sadece önceki öğrendiğimle bağlantı da kuramayabilirim. Ama hiç bir bağlantı yoksa ne günlük hayatımda ne önceki yasadıklarımda ne sonraki öğreneceklerimle, o bilgiyi öğrenmesi çok zor oluyor.
	Conditional Knowledge	• If I'm unsuccessful in a topic, the first reason is that it is not attract my interest or I listened it with a wrong method or studied with a wrong method. Zaten bir konuda başarısız oluyorsam en başta ilk etken ilgimi çekmiyor olmasıdır yada kesinlikle yanlıs bir yöntemle dinlemiş yada yanlıs bir yöntemle çalışmısımdır.

Appendix G

PSTs' Metacognitive Knowledge and Skills Revealed from Post Interview

Table G.1 Metacognitive knowledge and skills revealed from Selin case in post interview

		Quatations in post-interview
METACOGNITIVE KNOWLEDGE	**Declarative knowledge**	• I think, respond individually and respond as a group questios were distinctive for the manual. Bence, sorulari bireysel ve grup olarak cevaplamamiz bu dersin ayirt edici bir ozelligiydi. • Even you are right, there may be something that you can not see in an experiment. Hakli olsanız bile, o an deneyde göremediğiniz bir nokta olabiliyor. • I mostly used flowing charts while I was evaluating my learning in this course. Öğrenmelerimi değerlendirirken bu derste genelde flowıng chartlar kullandım. • We corrected our misconceptions in this course. For example, when we boil water, we thought that the bounds in water were broken instead they were weakened. Kavram yanılgılarını düzeltebildik bu derste. Mesela o bağların zayıfladığını kopmadığını. Biz bağlar kopuyor demiştik meğer zayıflıyormuş ya. Hani kavram yanılgıları vardı fenle ilgili. Hani çok iyi bir temeliz yoktu diyeyim ben. Onların bir kısmını düzelttiğimize inanıyorum. • One of my friend working at library learned something about metacognition and talked me what it is. While she was telling, I remember the questions in the manual and thought about the process of laboratory. Then I said my friend that they were measuring metacognition in our laboratory course. Arkadaşlarımdan biri kütüphanede çalışıyordu ve metacognition ile ilgili bir şeyler okumuş, onunla konuşmuştuk, anlattı ne olduğunu. Sonra laboratuar manualindaki sorular geldi aklıma. O an dedim ki arkadaşıma laboratuar dersinde metacognition ölçüyorlar dedim.

Table G.1 (continued)

	Procedural knowledge	I'm questioning the content of the lesson, the attitude of the lecturer, how to do homework, assessment of homeworks. Im questioning all of these things. Dersin içeriği, hocanın tutumu, ödevlerin yapılıp yapılmayışı onların değerlendirilişi, hepsini sorguluyorum. • I have understood that I do not have enough knowledge in some topics. For example, Tolga told that the more density of a liquid, the more time it requires to boil and he hypothesized it. I told him that it was not true. We tested the hypothesis and I understand why I was wrong and I correctecd my misconception. Bazı konularda yeteri kadar bilgim olmadığını anladım. Mesela Tolga demişti ki, yoğunluğu fazla olan geç kaynar gibi sanki bir şey yaptık. Ben de alakası yok dedim. Var mı yok mu? Mesela orada neyde hatamız olduğunu deneyde yapıp görüp o kavram yanılgılarını düzeltebildik yani. • I reorganized my knowledge in this course. Because we used to memorize the definion but with the help of examples and discussions I learned better here and reorganized my knowledge in this way. For example I considered subjectivity as a top concept which includes the other aspects of Nature of science. I mean subjectivity includes creativity, tentativeness and the other aspects. I reorganized nature of science aspects in this way. According to me, Aspects of nature of science refered six or seven branches before but now I organized other aspects as components of subjectivity. Bu derste bilgilerimi yeniden organize ettim. Çünkü önceden hep tanımlarını ezberledik ama burada yavaş yavaş örneklerle tartışmalarla falan filan oturdu onlar yerine tekrar organize ettiğim şeyler oldu. Mesela şeyi duşundum en son öznelliği diğer alt boyutları da altına alan büyük bir küme olarak duşundum mesela. Yani öznelliğin yaratıcılığı da kapsadığını, tentavinessı da kapsadığını hepsini hemen kapsadığını düşündüm yani mesela tekrar öyle organize ettim kafamda.Yani eskiden bilimin doğasının boyutları deyip

Table G.1 (continued)

		6, 7 tane kol varken hepsi simdi öznelliğin içinde bir alt küme diye düşünüyorum yani. • Previously, we did not write procedure in the group then we learned how to write the procedure for the experiments. After writing the experiments we examined our experiment if it did not work, we changed the procedure. Önceden prosedür yazmıyorduk, prosedür yazdık sonra baktık oluyor mu olmuyor mu tekrar değiştirdik. • While I was rating myself, I was thinking on why I was rating as 4 and why I was not rating as 3 or 5. If I can not support myself, I decreased my rating. In fact, I did not rate myself as 5. Kendimi rate ederken düsünüyordum neden 4 isaretledim, su su sebeplerden e niye 3ü işaretlemedim yada neden 5i isaretlemedigimi yeteri kadar destekleyemiyorsam, o zaman bir altına yada bir ustune cıkıyordum. gerci 5 e hic cıkmadım gercide.
	Conditional knowledge	• Our learning styles are different. I have learned many things from my friends by discussing and making experiments. Therefore this laboratory course contributed to my learning. Öğrenme şekillerimiz çok farklı. Tartışmalarla, deneylerle arkadaşlarımdan o kadar çok şey öğrendim ki. Bu nedenle bu ders bana çok şey kattı. • At the end of the course, we draw a diagram to show what we learned in the lesson and organized our knowledge. We controlled our learning in this way as well. Dersin sonunda derste neler öğrendiğimizi göstermek için ve bilgilerimizi organize etmek için diyagramlar çiziyorduk. Öğrenmelerimizi bu şekilde kontrol ettik. • I have never rated myself as 5 out of 5 since we learned that scientific knowledge can change over time and we may make some experimental error. I took into consideration of all these things.

Table G.1 (continued)

		• Besides, if we have a different perspective for the topic, we may have different results. Therefore I have never rated myself as 5. Kendimi hiç 5 üzerinden 5 olarak puanlamadım. Çünkü bilimsel bilginin zamanla değişebileceğini öğrendik ve deneylerde hatalar da yapabiliyorduk. Bütün bunları göz önünde bulundurdum. Ayrıca konu ile ilgili farklı düşüncelerimiz perspektiflerimiz olabiliyordu o yüzden farklı sonuçlar da elde edebiliyorduk. Bu nedenle hiç kendimi 5 olarak puanlamadım.
METACOGNITIVE SKILLS	**Planning**	
	Monitoring	• During the laboratory activities I focused on what I thought before the group discussion, what we discussed as a group and then what our decision was and whether there was a change in my opinion Laboratuar aktiviteleri sırasında önce grup tartışmasından önce ne düşünüyordum ona odaklanıyordum, grup olarak ne tartıştık ve sonra kararımız ne oldu. Benim düşüncelerimde bir değişiklik oldu mu olmadı mı. • At the beginning, I could not organize my knowledge but later I learned how to organise by taking feedback. Besides, at the beginning, we started experiments without the procedure then we were confused then we learned writing the procedure. Başlangıçta bilgilerimi organize edemiyordum ama sonar dönütlerle nasıl organize edeceğimi öğrendim. Bir de, başlangıçta biz deneylere prosedür yazmadan başlıyorduk sonar kafamız karışıyordu daha sonar prosedür yazmayı öğrendik. • Because we had ideas in our mind and at the beginning we wanted to conduct the experiment instantly and did not write the procedure. When we had mistakes we could not find since there

Table G.1 (continued)

		was not a procedure. Then we learned the importance of procedure and wrote it before the experiment. Even there was a huge difference between the initial and final procedure, we had a procedure and when we had mistake we know which step to turn back and change. Çünkü kafamızda bazı fikirler var ve başlangıçta hemen o fikirleri deneyip görmeyi istiyorduk ve prosedür yazmadan ise koyuluyorduk. Bir hatamız olduğunda da nerede hata yaptığımızı bulamıyorduk çünkü elimizde bir prosedürümüz yok. Sonar prosedur yazmanın önemini öğrendik ve deneye başlamadan yazmaya başladık. İlk yazdığımız prosedür ile son prosedür arasında dağlar kadar fark olsa bile bir prosedürümüz var elimizde ve bir hata yaptığımızda hangi asamaya donup düzelteceğimizi biliyoruz. • I guesss, due to the effect of this laboratory course, I'm questioning very much. Sanırım bu laboratuarın etkisinden olsa gerek, çok fazla sorgulamaya başladım.
	Evaluation	• We questioned in every laboratory course why we were learning in this way and we made discussions and I may take these things model in my learning. Her laboratuar dersinde neden bu şekilde öğreniyoruz, nasıl öğreniyoruz bunları sorguladık ve bununla ilgili tartışmalar yaptık. Bunları öğrenmelerimde model olarak almış olabilirim. • Science is more understandable now. I used to fear of science, especially in high school, I hated chemistry, physics and biology. But now, I have been able to do it. Therefore, it is more understandable and easy for me. Bilim daha anlaşılır benim için su anda. Eskiden biraz daha korkardım hele lisede hiç alakam yoktu fizik kimya biyoloji ile. Simdi yapabildiğini görünce insan yani senin için somutlaşınca biraz daha kolay oluyor her şey. Öyle yani biraz daha kolaylaştığını düşünüyorum.

Table G.1 (continued)

		• My flowing chart in the 5th manual and 9th manual are different because I developed them according to the feedback I took from you. If you did not give me feedback every week, I cannot develop them. 5. ve 9. Laboratuarda çizdiğim flowing chartlar çok farklı çünkü sizden aldığım dönütler doğrultusunda kendimi geliştirdiğimi düşünüyorum. Eğer bana dönütler vermeseydiniz onları geliştiremezdim. • Im questioning what I have learned according to the objectives. I used to study according to the objectives and never look again to understand whether I attain these objectives. But now after studying, Im turning back to the objectives and ask myself whether I attain these objectives. If I do not remember something in the topic, I turn back and study again. Objektiflere göre neler öğrendiğimi sorgularım. Eskiden de dersin objektiflerine göre çalışırdım ama asla geriye donup bu kazanımların ne kadarını elde ettim bakmazdım. Ama simdi çalıştıktan sonra kazanımlara geri donup neyi ne kadar biliyorum yapabiliyormuşum falan onlara geri donup bakıyorum

Table G.2 Metacognitive knowledge and skills revealed from Deniz case in post interview

		Quatations in post-interview
METACOGNITIVE KNOWLEDGE	**Declarative knowledge**	• The most amazing part was the last question which was related to evaluation. No matter how much grade I lost, the most amazing part was there. Haa bir de sonda dersi dgerlendirme var ya, en eglenceli kısmı burası. Ne kadar puanım kırılırsa kırılsın en eglendigim kısım orası. • I could rate myself but initially I had problems in the explanation of the ratings and I lost some grades in this part. I rated myself as 5 out of 5 at the beginning but then the highest rate was 4 during the evaluation. Ratingleri yapıyorduk da açıklamada sorun yaşadık sanırım çoğu puan oradan gidiyordu. Başlarda sorun yaşamıstık. Başlarda 5 falan da veriyorduk sonra en yüksek değerimiz 4 oldu. • Think on something too much is tiring and there are a lot of things to ignore in dailiy life but in terms of scientific knowledge, there are a lot of things to inquire and to think on deeply and it is amazing. Çok fazla düşünmek aslında yoruyor insani hocam böyle her şeyin ayrıntısına bakarken ki o kadar umursanmayacak şey var ki günlük hayatta. Ama bilimsel bilgi acısından bakarsak muhteşem bir şey, sorgulanması gereken çok şey var • I really enjoyed this lesson very much. Hocam çok eğlendim ben bu donemde tek 8.40im bu dersti benim ama eğlene eğlene geldim
	Procedural knowledge	• The question that asked for drawing a diagram or concept map for our learning had not been asked in my previous lessons but I integrated this question to my lesson plans. For example as a quiz question I asked what they learned while making the experiment and I wanted them to show their learning on a diagram.

Table G.2 (continued)

		Kavram haritası ya da diyagram çizmemizi isteyen soru başka hiç bir derste yoktu ve ben bunu ders planlarımın sonuna da soktum. Quiz veriyorsam mesela işte şeylerini yaptırıyorum datalarını falan topluyorsun bu derste neler öğrendiniz ne öğrendiyseniz yapın. Yaz çiz ne yaparsanız. • While I was answering the last question in the manual I divided my answers in two parts. One part is my learning in the lesson related to the experiment and the other part is related to nature of science. Manüeldeki son soruyu cevaplarken, ikiye ayırdım ben o kısmı yaparken biri laboratuar kısmı deneyle ilgili yaptığım şey biride bilimsel bilgi NOS boyutları ile ilgili ne öğrendim. • While we were designing the procedure, we were discussing our individual procedure's lack points then we formed our group procedure by considering the discussions. Tartışıyoruz sonuçta. Orda biz çok tartıştık mesela işte seninkinin burası eksikti benimkinin burası eksikti dedik. Sonra hani birinin prosedürünün yarısını aldık birisinin prosedürünün yarısını aldık birleştirdik yani daha güzel bir şey cıktı ortaya • There was a certain procedure in the laboratory manual and it helped me organize knowledge. I mean the manual leaded me to organize. We also discussed our ideas in the group. Concept maps that I create at the end of the lesson were also helpful in this organization. Even, I used concept map in physiology lesson to organize my knowledge. I took a big paper and I organized the assays or the paragraphs in the book as colorful diagram and hang it on my wardrobe. I keep knowledge in my mind in this way for this lesson. Benim çok fazla yaptığım bir şey yoktu bilgilerimi organize etmem anlamında. Foyler yardımcı oluyordu zaten, orda belli bir prosedür vardı. O yönlendirdi yani. Biz kendi aramızda da tartışıyorduk. Kavram haritası gibi şeyler yardımcı oluyordu. Fizyolojide kullandım hatta yaparken. Kocaman bir kağıt aldım. Step step aşamaları yazdım. Oradaki sözlü ifadeleri kocaman sekilerle renkli bir asamaya getirdim dolabıma astım. Böyle aklımda tutuyorum.

Table G.2 (continued)

		• I could understand whether I understand the topic in the laboratory by ratings and the diagrams or concept maps in the last question. In addition, I could understand it by my manual grade and the discussions we made in the group. Son sorularda rate yapıyoruz kendimizi, öğrendiklerimizi kavram haritası seklinde yapıyoruz buradan da anlıyorum yani. Diğer arkadaşlarıma baktığımda notuma baktığımda da anlıyorum öğrenip öğrenmediğimi.
	Conditional knowledge	• The result was in the last question in the manual because you could see what one learned in terms of theoretical knowledge and experiment. Expressing our learning via diagrams or concept maps were really enjoyable Sonuç o son soruda çünkü hocam ne öğrendin her şekilde teorik bilgi de orada yaptığın deney de orada. Şekillere dökmek daha eğlenceli. • My confidence in science has increased in this course because I had not been active in the laboratory lessons. Even I did not use microscope when I was in high school. In terms of making experiment, managing these experiments, this laboratory course contributed me a lot of things. Now Im thinking that I can manage better my future laboratory course as a teacher. Laboratuar ile birlikte bir güven geldi çünkü ben sonuçta deneylerde aktif olmadım su ana kadar ki lisede bile mikroskobu uzaktan görmüş bir insanim. Millet kurbağa kesmiş biz bunu yapmıyorduk. O açıdan hani deney yapma, bir şeyleri yönetme mesela deney yapacağız fen laboratuarlarımız olacak okullara gittiğimizde, onları daha iyi yöneteceğimi düşünüyorum. • Constructing concept map takes a lot of time that you should find connection among concepts and revise it. It takes a lot of time but it is more permanent. At that point laboratory course help me yes. When I enjoyed in the diagram and concept map question, I integrated it into other lessons. Kavram haritaları ile bilgileri akılda tutması daha kolay olması. Aslında önceden öğrendiğimiz bilgiler

Table G.2 (continued)

		daha doğrusu üniversitede gittikçe daha fazla dersimiz oldu daha fazla okumamız gereken şeyler var. Hepsini de bir şekilde aklımda tutmam lazım aklımda ve eğlenceli hale getirmem lazım. Biraz zaman alıyor altını çizip geçmiyorsun ya da not alıp geçmiyorsun. Hani onu sekle dökeceksin renklendireceksin bir daha bakacaksın. Zaman aliyor ama daha kalici oluyor. Bu noktada lab yardimci oluyor evet. Orada concept map sorusunda eglenince derslere de entegre etmis olabilirim.
METACOGNITIVE SKILLS	**Planning**	• We selected our materials, formed our procedure according to the hypothesis we thought. Materyalllerimizi sectik procedurumuzu belirledik tabi ondan önce kafamızda bir hipotez olması lazımdı.
	Monitoring	• for example in our group, although the question was the same and I thought we designed same thing, everybody in the goup had different ideas. For example Selin made a model using her physics knowledge, Ela designed something related to chemistry and Tolga had totally a different idea. I also had some idea and compare mine with my friends and learned a lot of things from them as well. I noticed that scientific knowledge was tentative and subjective in this course by experiencing in the group. mesela bizim grupta, herkes aynı şeyi yapacagiz varacagımız şey belli mesela diyelim ama esra mesela parafilmle falan ugrasıyor sinem diyor fizikten gidiyor mehmet hep ayrı bir taraftan falan uçuyor böyle hepsinden ayrı bir şey öğreniyorsun fikirleri birlesitiryorsun sende de olan fikirler oluyor falan öyle yeni yeni şeyler öğrendim yorumlarını. Bilimsel bilginin net bir bilgi olmadığını farklı özellikleri oldugunu degisebilecegini subjectivitynin önemini falan • Group experiment was more reliable because we designed it by discussing with group members and formed it. When a member did not see a detail, other member saw it. I usually rated my group design higher. For example if I rated my individual design as 3, I rated group design as 4 out of 5. Grup deneyi daha kesindi bence çünkü 4 kişi birden tartışıp bir şey çıkardık ortaya. Birinin görmediği bir ayrıntıyı diğeri gördü daha fazla emin olduk gibi bir şey. Yani bireysel olsaydı kendime 3 verip gruba 4 verirdim. Bir bakayım kaç vermişim.

Table G.2 (continued)

		• In our either biology or chemistry laboratories, every procedure was certain, what you would do was certain, how much matter you would use was certain and I need not think anything. But in this course, we designed our experiment and we selected our material. We asked you what we did and you answered us with another question and wanted us to perceive our friends. It was totally different. I force myself to think every detail. Biz biyolojide de olsun kimyada da olsun ki en kötüsü kimya çünkü prosedür belli yapacağın işlem belli, neyi ne kadar koyacağın bile belli sana bir şey kalmıyor. Hatta çoğu zaman asistanlar bile araya girebiliyordu. Hata geçen sene biyolojide biz bir laboratuara girdik slaytta şekiller var hayvan şekilleri. Hayvan sekilerlini çizdik ve çıktık. Sabahın köründe kalktık hayvan çizdik 20-25 tane föye , güya sınıflandırma. Kalktık gittik sonra. Her şey belli. Burada prosedürü biz belirliyoruz, kullanacağımız aletleri biz belirliyoruz. Hocam doğru mu yapıyoruz diyoruz. Ben böyle düşündüm diyoruz. Siz arkadaşlarınızı ikna edin diyorsunuz. Farklı yani. Bariz bir fark var. • Another different thing in this course was individuality. In our other lesson when we worked as a group, our individual thoughts were not asked. But in this course we wrote both our individual thought and individual experiment design and then compared them with group members'. This laboratory course was more detailed and four hours were not enough. Burada bireysellik çok fazla, orda onların istediklerini yapacağız onların dediklerini bulacağız falan yani. Ha bir de şey kısmı da farklıydı. Bir kere grupça çalışıyorduk, diğer derslerde bir deney yapılıyordu ama burada bir bireysel yapacaksın hani fikirden geçtim kendin de ayrı bir deney yapacaksın sonra onları kıyaslayacaksınız grup modeli çıkaracaksınız sonra oradan devam edeceksiniz falan yani. Birçok aşaması vardı bunların daha ayrıntılıydı. 4 saat yetmiyordu dolu dolu geçiyordu. • Before taking the course, when I met a formula, I did not question how that formula was revealed and when I asked someone the reason, I was told to memorize it because it was a formula and certain knowledge. But now I have learned that knowledge can be changed and how scientific knowledge has been improved and changed. For example now Im thinking on subjectivity and its

Table G.2 (continued)

		effect on scientific knowledge and I now question what scientists found and I do not accept knowledge as certain. Hocam mesela şey diyorduk önceden bir formül çıkıyor bir bilgi çıkıyor diyorduk ki tamam sorgulama ezberle. Bu neden böyle diye sorduğunda da bu formül çünkü böyle ezberle bunu ezberle. Tamamen kesin bilgi olarak bakıyorduk. Ama simdi o bilginin değişebileceğine o bilimsel bilginin o formüllerin nasıl ortaya çıktığını nelerin… Mesela şeydi sadece bilimsel bilgiyi değil de onun öznelliği de isin içine soktuğunu hayal gücünü de kullandığını düşününce de bilim adamlarının onların ortaya çıkardığı şeyleri sen de sorguluyorsun. Her şeye kesin gözüyle bakmıyorsun yani. Kolayını almayacak hale geldik. • For example in black box activity, someone from other groups thought shaking the box. None of our members in the group did not thought this. We thought observation was only smelling, observing the shape etc. We did not think shaking, touching, looking from a different perspective as observation. We began to be careful about observations. There were a lot of details in observations. Black box foyune bakalım. Burada mesela biz mesela hepimiz baktık sadece. Diğer gruplardan bir tanesi gidip sallamayı akıl etmiş mesela. O grup olarak hiç birimizin aklına gelmemişti mesela Biz sadece gözlem deyince, sekli rengi kokusu falan derdik ya, sallamak, dokumak ellemek, başka bir tarafından bakmak falan daha şekillendi. Ayrıntılar daha fazla. • Before this course, I did not consider “why questions” as detailed. At the beginning of the course I lost a lot grade since I did not jusftify my answers and I began to think on why questions and tried to explain. Even we explained our answer even if the question did not ask us to explain. We developed such a mechanism that we felt to explain our each answer. Why sorularına o kadar ayrıntılı bakmazdık böyle. Baktık ki puan gidiyor, açıklamalıyız bunları, test etmemiz gerek. Neden boyle dusundugumuzu soruda sormasa bile artik aciklar hale gelmistik. Oyle bi mekanizma olusmustu bizde.

Table G.2 (continued)

		We learned how scientists worked and the steps they developed for the experiments. They did not have a certain process and we noticed that every scientists did not make experiments. I had not considered it before. I always thought that there was a certain procedure that all scientists followed. I learned in high school that they made observations then wrote hypothesis, made experiments then. if it was proved it became a theory then a law. But I changed all of these thoughts in this laboratory course because I saw that there was not a certain procedure which was step by step. Bilim adamlarının nasıl çalıştığını gördük. Hangi aşamalardan geçtiklerini gördük. Step step gitmediklerini, herkesin deney yapmayabileceğini de düşünmüştük. Bunu daha önce hiç düşünmemiştim. Aklımda bir prosedür vardı hep. Önce gözlem sonra hipotez sonra kontrollü deney yapılır sonra teori olur sonra kanun olur seklinde diye öğrenmiştim lisede. Zaten o sırada çok da sorgulamazdım. O açıdan o bilgi bende öyle kalmıştı. Ama bu laboratuar dersinde fikirlerim değişti çünkü yaptığımız deneylerde de step step bir proses gitmiyordu. • We worked here like a scientists. Differently from us, scientists study much more than us and they thought on details more and they can extend their knowledge. Biz buarada aslinda bilim adamlari gibi calistik. Onlar bizden farkli olarak bir konunun uzerine cok fazla egiliyorlar, cok fazla zaman ayiriyorlar ayrintilar uzerinde daha fazla calisirak ellerindeki bilgiyi genisletebiliyorlar. • I have been questioning my observations more detailed. For example my viewpoint to the standing water on the road has been changed. One day I was walking with a friend and saw standing water on our way and I stopped and observed it. It was foamy and I began to thinking on why it was foamy. My friend forced me to go on our way and I reminded our lesson in the laboratory and talked about it to my friend. Daha sorgular şekilde bakıyorum. Daha önce de söylemiştim. Yerdeki su birikintisine bakış açım değişti. Böyle köpüklü köpüklüydü. Acaba buraya ne döküldü, bu su neden böyle oldu diye. Arkadaşım gidiyor böyle. Az dur dedim geriye donup baktım falan böyle. Off Birgül hoca dedim sonra.

Table G.2 (continued)

Evaluation	• I think the quality of my concept maps was getting better as the laboratory courses were progressing. Laboratuarlar ilerledikçe çizdiğim kavram haritalarının ya da diyagramların kalitesi gerçi siz daha iyi bilirsiniz ama bir iyileşmeye doğru gidiş var diye düşünüyorum. • I think the questions in the manual were designed to make us think on question more detailed and to take our individual thoughts and comments. These things leaded us to find something different. For example we were asked to express our thought on evolution instead of regular questions including only theoretical knowledge. Manualdaki sorular bence bir şeylerin üzerine daha ayrıntılı düşünmemiz için tasarlanmıştı. Bir de bizim bireysel düşüncelerimizi yorumlarımızı almak üzerine kuruluydu. Bunlar bizi farklı şeyler bulmaya yönlendirdi. Mesela evrim nedir gibi teorik bilgiler yerine bizim evrim hakkındaki düşüncelerimizi sordu. • This course contributed to my scientific knowledge and other courses. I do not say that I should memorize this now. I'm questioning the scientific knowledge in other courses and I know the tentativeness and subjectivity features of knowledge. I used to think that scientists found everything and we were the top of the technology. However now when I look a machine, I make comments that it should have this feature and I know that it can be developed. This course was adequate regarding to scientific knowledge. Bu ders bilimsel bilgi ve derslere yönelik olarak çok fazla şey kattı. Bunu ezberlemeliyim demiyorum artik. Derslerde sorgulama yapmıyordum ve kesin olarak düşünüyordum onları. Mesela teknoloji gelişiyor sürekli insanlar bir şeyleri buluyor ama sen oturuyorsun hadi bir şey bulayım dedin. Onu da buldular, sunu da buldular, bence en üst noktadayız artık bulunacak bir şey yok diyorsun, en azından ben böyle diyordum. Ama simdi bir alete baktığım zaman, sunun su özelliği de olsa çok güzel olurdu, şurasını da şöyle yapsalar diyorsun, üzerinde durduğunda akademik bilgin de olduğunda, o aleti gelistirebilebilirsin yani daha büyük adımlar atabilirsin o açıdan farklı. Bilimsel açıdan yeterli oldu bu laboratuar. • I had said myself that I could not make an experiment or I could not do that. I think I had had some self confident problem. But during the experiments here I said myself that there may be a missing point I ignored and made the experiment again. I had this change and I think it is important. I'm happy for that change.

Table G.2 (continued)

	Önceden deney yapamam ben bunu yapamam derdim güvenle ilgili bir sorun sanırım. Simdi de gözden kaçırdığım bir şey var bir daha deneyim diyorum. Öyle bir değişiklik var. Bu da önemli bir şey bence. O açıdan sevinçliyim yani. • I had difficulty in explaining why questions. To be able to justify the answers, I needed the examples and I had difficulty in finding these examples as well but I forced myself to overcome these problems and I think I improved myself in both justifications and support my answers with examples. Why sorularını açıklamada zorlanıyorum. Düşünüyorum ama bunu örneklerle açıklamak zorundasın. Oralarda eksiklik oluyor onu fark ettim. Daha fazla ikna edici konuşmaya ihtiyaç duydum. Onun haricinde zorluk yasamadım. Başlangıçta çok fazla örnek vermiyordum ama sonradan kendimi zorladım bu konuda.

Table G.3 Metacognitive knowledge and skills revealed from Ela case in post interview

		Quatations in post-interview
METACOGNITIVE KNOWLEDGE	**Declarative knowledge**	• The content of this course such as the thinking style of scientists, science process skills and nature of science was totally different for us. zaten bu dersin icerigi bize cok farklıydı. Bilimin dogasi olsun, hani bilim adamının dusunus sekli bilimin işleyisi bunların hepsi zaten uzak kavramlardı bu senenin basına kadar. • Up to now, nobody was interested in what I thought but in this lesson you have wondered what I think. Şu ana kadar kimse derste benim ne düşündüğümle ilgilenmemişti. Ama bu derste siz benim ne düşündüğümü merak ediyordunuz. • How much I'm confident in science learning, Im rating myself as 3 out of 5. Before this labortory course I would rate myself as 1. Kendime Fende ne kadar güvendiğimi puanlasam, 5 üzerinden 3 olarak puanlarım şuan. Ama bu dersten önce 1 olarak puanlardım. • We have learned what science is instead of the content of science. Bilimin iceriginden daha cok bilimin ne oldgunu ogrendik föylerle birlikte. • I really like this course very much. I did both learn and enjoy. Bu dersi çok sevdim ben. Hem eğlendim hem öğrendim dersler sırasında.
	Procedural knowledge	• I have had some knowledge related to the topics in the laboratory but I discovered scientists' thinking process. For example in young experiment, I discovered it by making experiment. In this experiment I have already known light travels along a straight line, it still travels in that way but

Table G.3 (continued)

		when the slits were included the experiment I reinterpreted my knowledge and developed the model. If the model does not explain the experiment, I reinterpreted my knowledge again. I have discovered how scientists do this and develop their knowledge. Bilgileri söyle geliştirdiğim oldu. Bilgileri ben zaten biliyordum ama bunu bilim adamı nasıl düşündü de o kanıya vardı onu fark ettim. Bir young experimentta deneyerek gördüm ben bunu. Hani oradaki bilimsel bilgide ışık basta böyleydi doğrusal yayılıyordu hani hala doğrusal yolla yayılıyor ama önüne başka bir veri verildiğinde onu tekrar yorumladım. Baktım açıklamıyor mu, tekrar yeni yeni yorumlar kattım. Bu laboratuarlarda da bunu öğrendim. Hani zaten biliyordum ışığın dalgayla yayıldığını doğrusal yolla yayıldığını ama bilim adamı bunu bulurken hangi aşamalardan geçtiğini gördüm.
	Conditional knowledge	• I adjust myself according to the demand of the lecturer. If s/he wants me to memorize, I will memorize. If s/he wants me to think, I will think. Or if s/he wants me to carry out a project, I will do it. Hocanın beklediği şeye göre yani ben sekil alıyorum. Hoca ezber mi istiyor ezberlemeye çalışıyorum. Düşünmemi mi istiyor düşünüyorum ya da başka bir şey bir proje yapmamı mı istiyor yapıyorum. • I really have understood the topics in this course and while I was dealing with the problems in this course, I solved them based on my knowledge and logic. Additionally in the course, an experiment was presented and there were no wrong thoughts. If you can support your ideas with evidences nothing is wrong. Therefore I did not hesistate to tell my thoughts. Even if they are awkward, I told them and thought on them. Therefore, I do not think this course was based on memorization Ya bir konuyu gerçekten kavradım kavradığım konuda sorulduğu zaman sorular ona göre cevap verdim hani ezberden gitmedim verdiğim tüm cevaplar bana mantıklı yani tam anlamıyla bildiğimi düşündüğüm

Table G.3 (continued)

		şeyler oldu. Çünkü zaten laboratuarda şey vardı, deney veriliyor hocam ben böyle düşünüyorum ama yanlış mı düşünüyorum. Yanlış düşünme diye bir şey yok, kanıtlayabiliyorsan ne ala al tamam o da doğrudur dendiği için yani fikirlerimi söylerken çekinmiyordum hani ne kadar şey de olsa nasıl desem saçma da olsa hani söylüyordum düşünüyordum ona göre. O yüzden ezberden gittiğini düşünmüyorum bu ders için. • Two times, I rated myself as 5 and then return back and change my rate because we have personal error or material experimental rerror. Also, knowledge is tentative in science. İki kez kendimi 5 olarak puanladım ama sonra geri donup değiştirdim çünkü materyallerden ya da bizden kaynaklanan deneysel hatalar olabiliyor. Bir de bilginin değişebilir özelliği de var.
METACOGNITIVE SKILLS	**Planning**	
	Monitoring	• Before taking this course, when the concepts and subjects were being taught, I did not wonder the basis of the concepts or the subjects. But now I wonder these bases while developing the models. Bu dersi almadan önce konular kavramlar bize öğretildiği zaman biz onun arkasına bakmıyoruz. Formül veriliyor. Soru veriliyor yapıyoruz. Simdi hani bilimin gerçek hayattan bağımsız olmadığını gördüm. Bilim adamların bizden çok farklı bir insan olmadığını gördük o bakımdan iyi oldu. • Questions in the manual required to think on deeply. I mean I tried to explain how I think. Yes I made a model but how I did and what inspired me. Then I questioned what I think and how I think. Manualdaki sorular üzerinde derin düşünülmesi gerekli sorulardı çoğu zaman. Yani nasıl düşündüğümüzü anlatmamız gerekiyordu. Evet, bir model yaptım mesela ama onu nasıl yaptım, bana bunu yaptıran şey ne, nerden ilham aldım nerden esti bunu yapmak. Sonrada ne düşündüğümü ve nasıl düşündüğümü

Table G.3 (contiued)

		sorgulamaya başladım. • For example, if the activity is related to evolution, I consider my preknowledge about it. I look for what was given in tha manual then I think what Im thinking and I select the knowledge which are useful for that laboratory activity. Mesela evrim teorisi hakkında mı konuşacağız, onunla ilgili bilgilerimi gözden geçiririm. Neler biliyorum, bana verilenler neler föylerde ona bakarım. .. Neler bildiğimi düşünürüm ona göre işime yarayanları laboratuarda kullanırım. • My observation ability has been improved throughout this course. For example I only wrote what I saw in the first experiments but I have learned to be careful about the details and tried to write every detail in my observations in case they may be useful while interpreting the results. Bu gözlem olayında hani ilk deneylerden son deneylere kadar çok şey oldu mesela ilk deneylerde baktığımı yazıyordum. Ama böyle deney deney ilerledikçe daha detaylı gözlem yapmaya başladım her bir şeyi isimize yarar diye yazıyordum. Hani en ince detayına kadar bakıyoruz inceliyoruz iste ne o acıdan ben kendimi geliştirdiğimi düşünüyorum. • Everybody is affected by their pre knowledge. We have experienced this in the black box acitivity. In that activity, someof us designed a model based on physics, some of us designed it based on the cehmistry knowledge. Some people are good at biology and their model was based on it. I designed a model based on chemistry because Im good at it.

Table G.3 (continued)

		Herkes önbilgisinden etkilenir. Biz bunu black box laboratuar 5de gördük. Hani orda şey vardı, kimimiz fizikten gittik kimimiz kimyadan gittik çünkü benim hani kimyam iyidir ben kimyadan giderim öbür arkadaşım fizikte iyidir fizikten gider. Birisi biyolojide iyidir içerisine fare koyar bir şey yapar. O yani öznellikten kastım buydu.
	Evaluation	• In my first interview I told that my thinking ability was getting worse in this school. But I do not think like that anymore. I think on what I'm thinking and what I'm not thinking. Bu okul bana dusunmeyi unutturdu demistim ben ama artık oyle dusunmuyorum yani dusunuyorum. Dusunmedigimi dusunuyorum • Taking this course is useful for me in terms of both being a qualified teacher and changing my confidence level from negative to positive. Bu dersi almam benim icin iyi oldu, hem daha verimli bir ogretmen olmak acisindan hem de bilim derslerinde olan confidence levelimi degistirdi, iyi yonde.

Table G.4 Metacognitive knowledge and skills revealed from Didem case in post interview

		Quatations in post-interview
METACOGNITIVE KNOWLEDGE	**Declarative knowledge**	• The rating parts were very difficult for me. Ratingler benim için çok zordu. • I could rate myself but I could not write the reasoning for the rating. rating yapıyorduk ama açıklamasını yazamıyorduk • I do not think the rating questions contributed something to me. Bilmiyorum hocam ama bu ratingler çok bir şey katmadı bence. • The significant differences in this laboratory were that we draw and planned models and experiments. Those thinngs were nice, I think. To sum up the lesson we made discussions and summarize what we learned individually in the last question. That was difficult but it was also useful and nice. Farklı olan model çizmemizdi. Model tasarlamamız. Bence o da güzel. Ne anlamda güzel dersek. Konuyu toparlama anlamında. özet olarak ne öğrendigimi göstermek anlamında güzeldi. biraz zorluyor ama olsun guzeldi. • The last question in the manual contributed us to develop our creativity. I think the objective of that question was that. Besides, it provided us to revise and show what we learned with a summary. Son soruda bence yaratıcılıgımız gelisiyor. bence tek amacı da o yani. bilgileri az detayla ama öz bi sekilde verebilmemizi saglıyor. • I think the aim of this laboratory course was learning NOS. We also made experiments and used our physics, chemistry knowledge but the main obejctive was the NOS. We also had laboratory course in biology, chemistry and phyics courses but they did not mention NOS.

Table G.4 (continued)

		burada amacımız bilimin dogasini öğrenmek. deneyler yapıyoruz tabi ama fizik kim biy bilgilerini kullanıyoruz ama ogrenmek istedigimiz asıl gelmek istedigimiz nokta bilimin dogası. biyolojide fizik ve kimyada da lablar yaptık ama orada yaptıgımız lablarda bunlara hic onem vermedik • Generally, I did not have have problems in learning science topics but laboratory course was more efficient for learning these topics. Up to now, what I learned in the laboratory course was more easy to remember. Maybe I will forget a liitle of them but I think that I will remember most of them. Genel anlamda fen konularını öğrenmemde bir problemim yoktu ama laboratuar daha etkili oluyor fen konularını öğrenmemde öyle düşünüyorum. Şu an laboratuarda öğrendiklerim daha kalıcı benim için. İlerde de hatırlayabileceğim şeyler. Belki bazı şeyleri unutacagim ama zaten bir zorluk çekmiyordum ama laboratuar daha etkili oluyor onu da es geçmemek lazım. • While I was filling the manual, I had to check my pre-knowledge. Zaten bu föyleri doldururken zaten kendi bilgilerimi bir kontrol etmem gerekiyordu. • This laboratory course was useful to remember our preknowledge. Böyle bir bilgilerimizi hatırlama konusunda iyi oldu bu laboratuar. • This laboratory course was very useful but it was very tiring. That term was very busy with the projects and we sometimes exhausted in that laboratory course. Laboratuar güzel ama yorucuydu bence. Neden derseniz çünkü bizim 3.sınıf I.donem çok yorucu. Hani 434 dersimiz 329 proje dersimiz çok yoğun ve yorucu o yüzden bu laboratuar dersi çok kasıyor ama kassa da güzeldi.

Table G.4 (continued)

	Procedural knowledge	• In the black box experiment, I remembered an experiment which I made in our method course. We opened three holes on the bottle and closed them with paraffin. When we opened the first hole, water did not flow but when the second hole was opened, water began to flow and if we filled water above the second hole, we would take more water than we put. We did it in the black box activity. Among a lot of individual models, my group decided to make my model and that made me very happy. blak boxta. sey yapmıstım ben 343 dersinde bir deney yapmıstım o gelmisti aklıma uc tane delik acıyor pet siseye ve onu sarıyoruz parafilmle. ondan sonra su dolduruyoruz. ilk deiligi actıgımızda bakıyoruz su akmıyor ama 2.deligi actıgımızda su akmaya baslıyor ve o deligin üst seviyesine biraz daha fazla su doldurdugumuzda daha fazla su elde etmiş oluyoruz bunu yapmıstık mesela hani bir suru grup modeli vardı ama benim dedigim olmustu. • While I was evaluating my learning, I benefited from discussions. If I had some idea to contribute to the discussions, I thought that I learned something. Additionally to discussions, I came you to take my manual feedback and I saw my mistakes and learned what to improve. I learned in this way. Öğrenmelerimi değerlendirirken, tartışmalar yaptık. Onlarda bir yorum yapabilmek bile bence fikrimizi söyleyebilmek öğrendiğimizi gösterir. Onun dışında zaten şey işte bunlar föyler okundukça, sizin yanınıza geliyorduk siz dönütler veriyordunuz falan. Orada da eksikliklerimizi görüp işte kendimizi nerelerde geliştirmemiz gerektiğini öğreniyorduk. O şekilde de öğreniyorduk
	Conditional knowledge	• My learning in this laboratory course was more meaningful beacuse we designed our experiments and made discussions related to the experiments and our learning. Everybody made different things and we examined them. Knowledge was more permanent with the help of these things. In terms of the learning, I prefer being active instead of reading slides in a course.

Table G.4 (continued)

		Bu laboratuarda öğrendiğim şeyler benim için çok anlamlıydı mesela önümüze bir materyal konuluyor onunla ilgili bir şeyler yapıyoruz tartışma yapıyoruz bu laboratuarda neler yaptık. Herkes farklı bir şeyler yaptı onları inceliyoruz falan. Bunlar iste bilginin daha kalıcı olmasını sağlıyor bence. Hani normalde hoca slaytları açıp anlatmasındansa bir şey yapmak benim için daha iyi oluyor öğrenme açısından daha kalıcı oluyor. • I had difficulty in individual questions. Maybe sometimes I had not enough knowledge to develop a model or I could not think or I had not been active in laboratory course very much or my scientific knowledge was not enough. Maybe due to these reasons, I had difficulty in individual questions. If you ask whether these individual questions were useful, yes they were useful for me. I forced myself to think and design somethink and I thinkt that my individual thoughts have been developed. Ya şey bazen hani ben çok zorlandım hani bireysel olarak geliştirmekte. Belki bu konuda bilgim yetersiz yâda düsenemedim çünkü daha önceden yani lise hayatım boyunca laboratuar kullandık ama hani bu kadar etkili olmadı belki bundan kaynaklanan bir şey olabilir ya da ne bileyim bilimsel bilgim çok gelişmemiş olabilir kendim geliştirmemiş olabilirim o yüzden bireysel olarak çok zorlandım ama sorarsanız katkısı oldu mu oldu tabi ki çünkü neden işte kendimizi zorladık bir şeyler düşünüp ortaya koyabilmek için. Ve bence de bireysel olarak da düşüncelerimizin geliştiğini düşünüyorum. • Supporting the reasons for ratings were difficult for me because I asked myself how I could perceived the leacturer about the rating, I had to support my rating. Explanation of it was difficult Yaptığım ratingleri desteklemek zordu benim için. Biliyorum 4 olduğundan ama nasıl hocayı ikna ederim o kısmı zor işte. Hani kendini ifade edebilme kısmı zor diye düşünüyorum yoksa iyiydi. • I never rated myself as 5 out of 5 in the manual because we learned that scientific knowledge was tentative and maybe I missed something or I did not know enough knowledge to support my idea or there may be a current knowledge that I did not know. Due to these reasons I did never rate something as 5 in the manual.

Table G.4 (continued)

		Çünkü bilimsel bilgini değişebileceğini öğrendik biz sonuçta ben bir şeyler biliyor olabilirim ama bu bilgi değişebilir. Belki bildiğim yanlış belki yeni şeyler olustu ben okumadım geri kaldım o bilgiden o yüzden 5 vermedim hiç bir zaman
METACOGNITIVE SKILLS	**Planning**	
	Monitoring	• The useful thing in the individual questions was that I was aware of the different thoughts of my friends in the group and these different thoughts leaded us to design different things from each other. Aynı zamanda hani bireysel yapmanın da bir faydası oldu jani grup olarak yaparken herkesin ne kadar farklı dusundugunu gorduk ne kadar degisik seyler olacagını gorduk ve ogrendik hani bunları da ilerde kendimiz icin kullanabiliriz belki. • Even if the materials we used were the same, our models or experiment designs were different. For example in one of the experiments three of us in the group used ice in the design of our model in black box. However our models were totally different. Kullandığımız malzemeler aynı olsa bile, yaptığımız modeller aynı değildi. Bende buz kullanmıştım işte üstüne oda sıcaklığında su döküyordum erimesini falan şey yapıyordum. Ada galiba tuzlu su ya da gülsüm tam olarak hatırlamıyorum onların ne yaptığını da. Bir tanesi tuzlu su kullanmıştı diğeri de ne yapmışı onu hatırlayamayacağım. • I did not had difficulty in designing the experiments if I had enough knowledge. But sometimes while developing the models I did not consider theories, I considered my daily life experiences. Some of my models did not work, I understood that I shlould have used the theories and scientific knowledge in addition to my experiences.

Table G.4 (continued)

		Mesela bildiğim bir konuysa model geliştirmede zorlamadım. Önceden fizik bilgilerimizle bir şeyler cevirdik karaladık ama ya mesela buz geldi aklıma ama benim sistemim çalışmamış.Mesela kurarken çalışır mı çalışmaz mı, fizik kurallarını düşünerekten kurmadım ama onları da düşünmemiz gerekiyor. • I was inspired by my friends' design. Especially Buse designed very different things and I was inspired from them. Aynı zamanda bu bireysel sorularda arkadaşlar farklı yaptığı için mesela genellikle Buse farklı şeyler tasarlıyordu onun fikirlerinden baya etilendim açıkçası itiraf ediyorum. Güzel şeyler tasarlıyordu. • Our other laboratory courses did not include designing a procedure. Everything was given us and we did not need to design a thing. For example we compared our observations between the the first misroscope and second misroscope. Daha önceki laboratuar derslerimizde prosedür yazma ya da oluşturma yoktu. Şeydi mesela mikroskoplar hazır oluyordu preparatlar vardı onları inceleyip resmini çiziyorduk. 1. mikroskopla 2. mikroskop arasındaki fark nedir gözlemlerinizi yazın öyle bir şey yoktu zaten • I had some misconcepts and I changed them in this course. For example I had known that laws could not been changed. We learned here that they also may be changed in the light of evidences. Bazı kavram yanılgılarımız vardı ve onları değiştirdik. Mesela teori ve kanunda vardı bir de şey kanunlar değişmez diye biliyordum ya da kanunlar kanıtlanmıştır kesindir. Onlar mesela gitti. Kanıtlanmamıştır, değişebilir başka bilgiler de var falan filan onlar değişti yani. • Before taking this course, scientific articals did not interest me and I did not like reading them. However, I have been liking reading them now. Even I buy scientific magazine now and try to improve myself.

Table G.4 (continued)

		Ya laboratuardan önce ben böyle bilimsel bilgileri içeren yazılar okumayı sevmezdim hocam. İşte bilimsel şeyler pek ilgimi çekmezdi. Ama laboratuardan sonra hoşuma gitmeye başladı. Böyle şeyler okuyayım kendimi geliştireyim.
	Evaluation	• The question asking for drawing a diagram or concept map for our learning was difficult initially and I draw very simple things but as the labs were progressing and taking the feedbacks, I pretty much developed my drawings. Draw a diagram for learning sorusu için ilk basta zordu ve basit şeyler çizerek başlamışım. Sonra geliştirmişim kendimi. Şunda kendimi aşmışım. Şunda da biraz aşmışım. Şu da değişik olmuş iste. Ama gelişmiş yani. İlkine göre bakarsak baya bir ilerlemişim yani. • I have begun to question both scientific and nonscientific issues. My viewpoint has been changed. Bu laboratuar dersi ile birlikte sorgulayıcı oldum. İllaki bilimsel bir şeyde değil de. Bakış acım daha farklı değişti • I learned in this course how I could use my knowledge and how to teach my knowledge to my students and people around me. That was a very good thing for me. We both learned what science was and how to teach it. Bu derste bilgileri nasıl kullanabileceğimi öğrencilerime ya da çevremdekilere nasıl anlatabileceğimi öğrendim mesela. O yönden iyi bir şey mesela. Hani öğrenmekle kalmadık öğrendiklerimizi anlatmayı da öğrendik.

Table G.5 Metacognitive knowledge and skills revealed from Ada case in post interview

		Quotations in post-interview
METACOGNITIVE KNOWLEDGE	**Declarative knowledge**	• The rating parts in the course were completely new for me. Then there were a question which wanted us to develop a concept map or a diagram with regard to our learning in the course. It is also different for me. Rating kısımları benim için çok yeniydi. Bir de kavram haritası ya da flowing chart çizmemizi isteyen sorular benim için çok farklıydı. • If the objectives of this course were science concepts, nature of science, the course was well designed for that aim. Eger bu dersin amaci fen kavramlari, bilimin dogasi ise bunun icin cok iyi dizayn edilmisti. • I had difficulty in rating myself. I sometimes wished that the manual had not include the rating part. However it has contributed to my learning. Rating kısımlarında cok zorlandım. zaman zaman keske olmasaydı dedim ama mutlaka onun da bir katkısı oldu. • I feel more confident in learning science now. Şu an fen konularını öğrenirken çok daha fazla güveniyorum kendime. • I could not differentiate law and theory and I was sad about it but I have achieved to differenciate them. Teori ve kanun ayrımını yapamıyordum o konuda mutsuzdum üzülüyordum başarısız olduğumu düşünüyordum onu hallettim.

Table G.5 (continued)

		• I evaluated my learning in ratings and the diagram models that I draw at the end of the lesson. Öğrenmelerimi ratinglerle en son çizdiğim diagram modellerle değerlendirdim. • Sometimes an explanation of my friend could be useful for me to understand a concept or an explanation of my lecturer or an example she introduced. Bazen bir deneyde arkadaşımın bir açıklaması bile benim o kavramı almamda yardımcı olmuş olabilir ya da hocamın bir açıklaması verdiği bir örnek bile hatırlamıyorum çok özel bir örnek verememem ama sonuçta oturdu.
	Procedural Knowledge	• I have controlled my learning in this course by asking some questions myself from time to time. For example, what is theory, what is law, is there a relationship between theory and law. Zaman zaman kendime de soruyordum hani teori ne kanun ne? Ya da işte subjektiflik neydi aralarında bir ilişki var mı, yaratıcılık neydi onları zaman zaman kendime sordum. Ogrenmelerimi bu sekilde kontrol ediyordum. • I have questioned myself very much during this course. I have questioned my prior knowledge. I asked some questions myself. For example: Have I ever seen this? Do I familiar with this knowledge? How much thing do I know about this topic? Do I have enough knowledge to make inference, to interpret the results and discuss?, or Yes I observed something but how much do I confident about my observation? or… I do my observation via my five senses and how much can I trust in my senses? Or I make a measurement via ruler and how much accurate did I read? I have questioned like these things. Laboratuar dersinde çok sorguladım kendimi. Ön bilgilerimi çok sorguladım, ben bunu daha önce görmüş müydüm? Biliyor muydum? Bu konu hakkında ne kadar şey biliyorum. Ne kadar aşnayım yeterince bilgim var mı yorum yapacak çıkarım yapabilecek tahmin yapabilecek düzeyde miyim? Ya da tamam bir şey gördüm ama ne kadar yanılma payım var? Ya da bir şey gördüm tamam ama ne kadar

Table G.5 (continued)

		Yanılma payım var? Belli bir gözlem yaptım çıkarım yaptım ama ne kadar yanılma payım var nasıl hatalar yapabilirim. Atıyorum kronometre ile çalıştım onun hatasını göz önünde bulundurabilirim ya da hani gözlem yapıyorum duyu organlarımla yapıyorum ne kadar gözüme güvenebilirim. Ya da cetvelle ölçüm yapıyorum ne kadar doğru okudum bu tarz sorgulamalar yapabilirim.
	Conditional knowledge	• I feel that I have studied like a scientist in the course. I feel closer to science. Therefore, I think this laboratory course was useful for me. Laboratuarda şey oldu sanki tam bilim adamı gibi çalışmaya yaklaştığımı hissettim. Daha yakın hissettim bilime kendimi. O yüzden çok daha faydalı bir laboratuar dersi olduğunu söyleyebilirim. • For example if we rate ourselves as 4 or 3 out of 5 but why? Writing the reasons of this was more effective and I think that part was the most difficult. Actually, how accurate scientific knowledge is. Therefore, I have never rated myself as 5. I have always doubt but there were also some evidences. Due to these reasons, I both evaluate the evidences and consider the tentativeness feature of science while rating myself, my method or models. As a result, I neither rated myself as "not very confident" nor "very confident". Ratingler beni zorladi cunku dusundugum seyin ne kadar gecerli olup olmadığını anlamamda yardımcı oldu. Ya da hani tamam böyle olduğunu düşünüyorum ama neye dayanarak bunu söylüyorum ne kadar eminim o konuda bildiğim şeyi kritik etmemde yardımcı oldu ama çoğu zaman iste tereddüt yasadım. Ne kadar eminim emin miyim 3 mü vereceğim 4 mü vereceğim 2 mi vereceğim doğru olan nedir. O konuda iste sıkıntı yasadım. Beni en çok o kısımlar zorladı.
METACOGNITIVE SKILLS	**Planning**	

Table G.5 (continued)

	Monitoring	• The rating part help me understand how much valid what I thought. I have some idea but what the basis were for these idea and how much confident I was. This situation help me criticize my knowledge and most of the time I was uncertain about my rating. I have some difficulty in that part. Kendimi rate ettiğim kısımlar düşündüğüm şeylerin ne kadar geçerli olduğunu sorgulamama yardımcı oldu. Bazı fikirlerim vardı ama bu fikirlerin dayanağı neydi ve ne kadar emindim bunlardan. Bu durum bana bilgimi kritik etme şansını verdi. Ve çoğu zaman da ratinglerimden emin olamıyordum. Bu kısım benim için gerçekten de zordu. • In the previous laboratory lessons, we made the experiments that was given us and recorded the results then the course finished. We did not evaluate ourselves or make a relation with nature of science. Even nature of science was not pronounced. Bundan önce aldığım laboratuar derslerinde tamam yapmamız gereken deneyi tasarlıyorduk yapıyorduk sonuçları dataları yazıyorduk bitiyordu hiç bir şekilde kendimizi değerlendirme söz konusu değildi ya da bilimin doğası ile ilişkilendirme hiçbir şekilde yapılmıyordu. Ki o laboratuarlarda bilimin doğası adı geçmiyordu ve o zamanlarda öyle bir şey bilmiyordum. • Some questions were answered as a group and these questions were useful in terms of leading us discussions and being aware of the different thoughts of our friends. We can appraise our thoughts and investigate the common and different points. Im aware of that the only right thought is not mine and have a chance to meet different views. As well as group questions, individual questions were essential to evaluate ourselves. Soruları grup olarak cevaplamamız söyle bir kazanç sağlamış olabilir hani tartışma yapma sansımız oldu ya da bizden farklı düşünen arkadaşlarımızın fikirlerini öğrendik. Ha burada farklı düşünüyormuşum ya da eksik düşünüyormuşum diyebildik. Hani sadece benim bildiğimin doğru olmadığını, farklı bakış

Table G.5 (continued)

		acılarına sahip olabildik belki farklı bakış acılarından baktık olaylara böyle bir sansımız oldu grup aktivitelerinde. Bireysel de olması gerekiyordu değerlendirmek için kendimizi. • I noticed that I had a lot of misconceptions. For example, I could not differentiate theory and law, I thought that empirical based was only refers to making experiments. These thouths have been changed for me. That is enough for me to love and care the lesson. Therefore, I have never felt as close as science until taking this course. I have never had studied like this. I used to take physics cehemistry biology labortatory but I have never taken these course by thinking nature of science until taking this course. Ya bir kere çok fazla kavram yanılgısı varmış kafamda. Ben teori kanun ayrımını yapamıyordum ondan sonra subjektiflik, yaratıcılığı çok yakın düşünüyordum onun dışında hani emprical basedin sadece deney Yapmak olduğunu düşünüyordum bunlar değişti benim için. Bu yeterli bu dersi sevmem de önemsememde. Bu yüzden dedim fen bil. Okuyordum ama hiç bu kadar fene bilime yakın olmamıştım. Bu tarz çalışmalar yapmamıştım. Fen bil. Diyince sadece biyoloji fizik kimya laboratuarlarına sınavlarına giriyorduk ama hiç bilimi düşünerek fen alanında çalışmadım o acıdan söyledim • This course helped me to be aware of the lack points. For example I did not have knowledge about the theories, I did not know what observation means or I did not have enough knowledge for evolution theory. In addition, this course provided me an environment to test my knowledge. Bu ders eksik olduğum yerleri görmemi sağladı. Mesela, benim gerçekten teoriler konusunda bilgim yok. Örnek veriyorum gözlem ne demek bilmiyorum ya da evrim teorisini yeterince bilmiyorum. Bu tarz hani kendi eksiklerimi görmemde yardımcı oldu bu ders. Onun dışında nasıl katkısı olmuş olabilir. Bence bildiklerimi test etmek için uygun ortamlardı. • I think the content of the laboratory manual leaded me to question. It was not me to force myself thinking, questioning. I did not do these things by myself. If I could do this, I had done it in my previous laboratory lessons.

Table G.5 (continued)

		Beni sorgulamaya iten föylerin içeriğiydi bence. Hani beni sorgulamaya düşünmeye iten ben değildim kendi kendime şey yapmadım. Bu laboratuarda bunu düşüneyim bunu söyleyeyim hiç aklıma gelmemişti. Gelseydi daha önceki laboratuar derslerinde yapardım. Tamamen föyler ve sizlerdiniz.
	Evaluation	• Questions for concept maps and diagrams were very good. Firstly I did not designed good things but later I have developed them by thinking on them deeply and produced different things. I do not think Im very creative and these questions are partly related to creativity. For example firstly I used flowing charts but later I used pictures to express my evaluation. I think there was a change and improvement in the way of my evaluation type. I think this evaluation question is a type of summary which reflects what we learned throughout the lesson and we can evaluate and question ourselves about our learning. It was an effective method, I think. Kavram haritaları ve diyagram ile ilgili sorular çok güzeldi ilk başta güzel şeyler tasarladığımı düşünmüyorum ama daha sonra geliştirdiğimi daha fazla üzerine düşünerek daha farklı şeyler ortaya koyduğumu düşünüyorum. Çok yaratıcı bir insan olduğumu düşünmüyorum biraz yaratıcılıkla alakalı ama hıma. Mesela ilk basta flowing chartlar kullanıyordum sonra resimler konuşma balonları falan kullanmaya başladım. Gelişmeler olmuş değişmeler olmuş bence. Ki bence o laboratuarı değerlendirme acısından bir özetti sonuçta ne öğrendiğimizi yansıtıyordu. Kendimizi değerlendirebiliyorduk, sorgulayabiliyorduk ne öğrendik. Etkili bir yöntemdi bence • This laboratory course was useful for me that I feel closer to science. Although I'm at science education department, I was not aware of what Im learning or what science is and the feature of nature of science. I have ideas about all of these things now. Bu laboratuar dersinin bana söyle bir katkısı oldu bilime daha yakın hissediyorum kendimi hani tamam fen bil. Öğretmenliği okuyordum ama bu kadar farkında değildim ne öğrendiğimin ya da bilimin ne olduğunu, bilimin doğasını, bilimin özelliklerini. Bu sene çok daha iyi oturdu.

Table G.6 Metacognitive knowledge and skills revealed from Gamze case in post interview

		Quatations in post-interview
Metacognitive Knowledge	**Declarative Knowledge**	• The individual questions were difficult for me. O bireysel kisim bizim icin zor oldu. • The evaluation part of laboratory was interesting for me. We evaluated our learning and these ratings were difficult for me. Bir de dikkatimi çeken şey var hocam bu değerlendirme. Kendimizi değerlendiriyoruz. Bu ratingler de zorluyordu beni. • Actually I could rated myself. For example I rated myself as 3. But the explanation of why I rated myself as 3 and why I did not rate as 4 or 5 was difficult Aslında değerlendiririm kendimi 3 veririm 4 veririm ama onu açıklama kısmi bitiriyordu yani. 4 veriyorum mesela niye 4 veriyorsun diyorsunuz onu da açıklıyorum sonra neden 5 vermedin diyorsunuz o tip şeyleri açıklamada zorlandım. • We could support most of things with numerals in physics and chemistry but something in science like bilogy were required to explanation with words and this was not an easy issue for me. I had trouble with writing these explanations. Biz kimya ve fizikte sayılarla rakamlarla bildiklerimi açıklayabiliyoruz konuşmadan yazmadan ama biyoloji de ya da böyle bilim şeylerinde kesinlikle düşündüğünü yazmak zorundasın ama düşündüğümü yazmak bana zor geliyor iste açıklayamıyorum • I have noticed that I knew something wrong in theory and law. Bazı şeyleri yanlış biliyormuşum kanun ve teori de olduğu gibi onu fark ettim.

Table G.6 (continued)

		• This course not only gave theoretical knowledge but also gave the implication of nature of science. Bu laboratuar sadece teorik bilgi vermedi bilimin doğasının uygulama alanını da gösterdi. • I can rate my confidence in science as 50%. fen konularini ogrenirken kendime %50 guveniyorum suan. • Laboratory course helped me make my knowledge permanent. However, learning science is difficult in general. Laboratory concretize knowledge but this laboratory course made it abstract. Laboratuar bilgilerini daha kalıcı hale getiriyor. Laboratuar bunu yapıyor ama genel anlamda fen öğrenmek zaten zor bence bir de bilimde şöyle bir şey öğrendik bilgiler değişebiliyor kalıcı bir şey yok. Laboratuar daha somutlaşıyor ama bu laboratuar soyutlaştırdı. • This laboratory course had much to contribute to me in terms of questioning everything. Hocam her şeye sorgulama ile bakmak anlamında bu laboratuar çok şey kati bana.
	Procedural Knowledge	• We evaluated ourselves very much in this laboratory course. I was questioning how much our knowlege was right or wrong and how much confident I was. Actually there was a fact that if you did not make somebody something, s/he never did it. Although ratings were forced us, it was a good way to question our knowledge. It had to be in this way. Laboratuarda sonuçta zaten kendimizi sürekli değerlendiriyoruz. Bilgimiz ne kadar doğru ne kadar yanlış o yüzden o kısımda siz bize laboratuarın sonuna gelmeden bu işlemi tamamlattırıyordunuz. Aslında söyle bir şey var hocam birisine o isi yaptırmazsanız o yapmaz çoğunlukla dolayısıyla bu ratingler evet bizi zorluyor ama aslında bizim kendi bilgimizi sorgulamak için iyi bir yol. Maalesef böyle ama çok zorluyor

Table G.6 (continued)

	Conditional Knowledge	• In addition to ratings, I had difficulty in the last question which includes showing our learning on a diagram or concept map. That question required us to be creative and I thought that I was not enough creative to answer that question properly. I lost most of grade in that question. Ratinglerin yanında en zorlandığım kısım manüeldeki son soruydu hocam. Hani bizden kavram haritası ya da flawing chartla dersi değerlendirmemizi isteyen soru. Bu soru bence yaratıcı olmayı gerektiriyordu ve ben çok da yaratıcı değildim bu soruları cevaplamak için. Zaten çoğu puanımı da bu soruda kaybettim maalesef. • While making experiments with friends, I can told my ideas and contributed to the experiment. Additionaly, I was inspired by my friends' ideas. However, I could not focus on individual questions in the manual and I needed to ask questions to my friends. May be those were the reasons that the individual questions were difficult for me. Deneyleri yaparken arkadaşlarla tartışırken orda fikirlerimizi söylerken orda katkıda bulunuyorsun ama öyle bir şey oluyor ki arkadaşının sana söylediği şey ilham veriyor ama tek başına olduğunda hiç bir şeye o an odaklanamıyorsun belki ondan da olabilir ama bir şekilde zorlanıyordum tabi
Metacognitive Skills	**Planning**	
	Monitoring	• I think the most enjoyable part was discussions because I like talking and listening other people's thoughts. I could support my ideas or I could change my thoughts if my friends refutated me. Thanks to discussions I was aware of the different thoughts. Bence en güzel kısmı tartışmalardı çünkü ben konuşmayı çok seven bir insanim ama şey böyle konuşarak insanların farklı düşünceleri olduğunu anlıyorsun ve kendi düşünceni ya daha iyi destekliyorsun onlara karşı cevap vererek hem de onların bilgilerini belki de kendi bilgilerinin gereksiz olduğunu anlıyorsun ama öyle bir şey oluyor ki farklı farklı insanlardan herkesten yararlandım ben çünkü hepsi farklı farklı yerlerden bakabiliyordu o yüzden tartışma kısmı daha güzeldi. • This laboratory course was related to creativity and thinking. Additionally, I think you gave us abstract things in this course. It was always related to thinking.

Table G.6 (continued)

		Bu laboratuar dersi yaratıcılık ve düşünme ile ilgiliydi daha çok. Ayrıca bu benim düşüncem tabi ama siz bize daha çok soyut şeyler verdiniz bu derste. Sürekli düşünmeyle ilgili olan şeyler. • I have understood in this laboratory that I had to success something alone and I had to think quickly to make decision. Because the manual asked for our individual thoughts and we had limited time to express them. Bu laboratuarda anladım ki mesela böyle tek başına da bireysin ve bazı şeyleri tek başına yapmak zorundasın. Çünkü manüel bizim bireysel düşüncelerimizi soruyordu ve bunları ifade etmek için kısıtlı bir zamanımız vardı.
	Evaluation	-

Table G.7 Metacognitive knowledge and skills revealed from Buse case in post interview

		Quatations in post-interview
METACOGNITIVE KNOWLEDGE	**Declarative knowledge**	• The questions in the manuals directed us very well Bence manualdaki sorular çok güzel yönlendirici sorulardı. • There were questions in the manual aimed to detect our preknowledge for the topic and they were also open to discussion. Additionally, they leaded us to interpret our knowledge Foydeki sorular çok yoruma acık tamamen bizden yorum bekleyen ya da bizim şeyimiz şey bile vardı, ne biliyoruz bu konuda. Onu tespit etmek için bile sorularınız vardı mesela. Kesinlikle sadece şunun şunun cevabı nedir, ya budur budur degilde cok yoruma acık sorulardı. Bir de, sorular bildiklerimizi yorumlama uzerineydi. • The basis of the course was what we knew, how we learned, how other friends learned and how to evaluate our learnings. Bu laboratuar aslında daha çok bizim ne öğrendiğiniz üstüne ve biz bunları nasıl öğrendik ya da iste duygu nasıl öğreniyor ben nasıl öğreniyorum o ne anlamış ben ne anlamışım çünkü aynı derse giriyoruz. Bence daha çok onun üstüne kuruluydu. • I think nothing was based on memorization in that course and I did not need to study anything for the exam since we practiced and experienced everything in the course, I remembered everything easily. Bence hiç bir şey ezbere değildi yani mesela sınav için hiç bir şey çalışmama gerek kalmıyordu çünkü laboratuarda yapmıştık zaten

Table G.7 (continued)

		• I think nature of science aspects were related with each other although they were given as separate titles. It was impossible to consider them independently. NOS boyutlarinda ne kadar birbirinden ayrı isim isim olarak gözükse de hepsi birbiriyle iç içe bence o kadar bağlantılı ki birini birine bağlamamak mümkün değil. • This course even contributed a lot of things to evolution topic. Evrime bakışım açısından bile bu ders çok şey kattı yani. • I had difficulty in ratings at the beginning but later I got used to them. Baslarda ratinglerde çok zorlandım ama sonradan alıştım onlara. • I have tried to connect subjects. For example I have tried to link what I know in biology to a physic experiment in this course. Her şeyi birbiriyle bağdaştırarak düşünüyorum. Ya mesela biyolojide bildiğim bir şeyi burada yaptığım fiziksel bir deneye katmaya çalışıyorum mesela.
	Procedural knowledge	• I did not rate anything as 5 out of 5 and I asked myself why I did not trust that knowledge, what I missed or why I trusted that knowledge very much. I have considered on my own thoughts and revised nature of science while asking these questions myself. Hic bir zaman 5 isaretlemedim ratinglerde, ama arada cok gidip geldiklerim oluyor neden güvenmiyorum bu bilgiye diyorum mesela, neyi eksik yapmıs olabilirim yada neden cok guveniyorum neyi tam yapmıs olabilirim. Kendimde böyle bir seyleri dusunmek, kendi düsünmem bilimin dogası zaten gözden gecirme anlamına geldigi icin.

Table G.7 (continued)

		• I think we were forced to think multidimentionally. For example, possible observations. I made observations and then I thought whether I made all possible observations. Ok I could not guess exactly where the topic would move on but I revised my observations and asked myself whether I made all possible inferences. For example I did not made an observation or inference related to smelling. Additionally there were not any restriction on hypothesis and I thought on alternative hypothesis. Bir de bu laboratuarda çok yönlü düşündük bence o kadar zorlandığım anlar oldu ki mesela bir şey düşünüyorum ya diyorum bu düşünce sığ olmuyor belli bir noktaya vardırmıyor mesela o kadar farklı acılardan düşünmeye zorlandım ki, mesela olası gözlemler, gözlem yapıyordum mesela sonradan düşünüyordum bütün gözlemleri yaptın mı mesela tamam konunun nereye gideceğini tam olarak bilmiyor olabilirim burada hangi gözlemleri yaptım baktım kokusu ile ilgili bir şey yapmamışım ya da onunla ilgili çıkarımda bulunmamışım ayada iste ne bileyim hipotez kurarken mesela o kadar farklı hipotezler kurulabilecek konular vardı ki bazen yani hiç bir sınırlandırma yoktu orda mesela orda konu bu su hipotezi de kurabilirsin baksa da ötesi yok. • I learned by constructing my knowledge in this course. For example, every manual included an instruction part which gave knowledge about what we would learn. In that part I checked my knowledge whether I had any misconceptions. Then I learned new things on that introduction knowledge and I made connections with my preknowledge. I constructed my knowledge by experiencing, making conncetions between new knowledge in the laboratory and preknowledge throughout the laboratory course. Bu laboratuarda bilgilerimi hep bir biri üstüne yapılandırarak öğrendim. Mesela foylerin başında o foyun ne ile ilgili olduğu ile ilgili bir giriş kısmı var. Onu okuyorum, bir kavram yanılgım var mı ona bakıyorum. Sonra o laboratuarda öğrendiğim ek bilgiler oluyor. Bir sonraki laboratuarda öğrendiklerim bir önceki ile bağlantılı oluyor ve bir biri üstüne inşa ederek öğrendim tüm laboratuar boyunca. Kendimiz deneyerek eski bilgilerimizle de bağlantı kurup yenilerini de üzerine ekleyerek öğrendim.

Table G.7 (continued)

		• Activities and experiments were very useful to control my knowledge. For example when I was failed in something, I had chance to overcome this failure. I could made this correction in experiment or in group discussion or in the middle of the lesson that I asked a question or your questions helped me overcome my failure. I could both controled my knowledge and corrected the misconceptions in this way. O aktiviteler ve deneyler o kadar çok kendi bilgimi kontrol etmeme faydalı oldu ki, yani mesela yanlış biliyorum doğru biliyorum başarısız oldum okudum bilmiyorum deneyin belli bir aşamasına geldim grup aktiviteye geçtim başarısızlığımı bir şekilde orada düzeltebiliyorum ya da ne bileyim yanlış gözlem yanlış çıkarım olabilir. Tartıştık artık grup olarak bir şeyler yapmaya başladık orada düzeltebiliyorum ya da buraya vardığımda hani fark edebiliyorum o yüzden kendi bilgimi bu şekilde şey yapabiliyorum yani.
	Conditional knowledge	• I have never rated myself as 5 out of five in the manual. Because there were a lot of error types. Before taking this course, I only thought the errors due to five senses. For example we feel cold as if it is warm or we feel warm as if it is cold and sometimes our eye make mistakes just like related to colurs. I thought that making true observation is impossible. In addition to errors resulting from our five senses, experimental errors could happen. In addition to these errors, scientific knowledge can be changed by new data or observation. We learned subjectivity feature of nature science and scientific knowledge can not be certain or absolute. Therefore rating myself, my method or model as 5 would be ridiculous. I genereally rated myself as 4 or 3 out of 5 if I thought that I made all possible observations and had enough knowledge for the topic. But sometimes I felt that my brain was not working and could not think. At these times since I did not trust my observations and knowledge, my ratings were lower than 3. Ben hep duyular acısından bakardım, bilimsel bilgi açısından değil de çünkü mesela göz yanılmaları iste duyularımızda yanılmalar iste bazen sıcağı soğuk gibi, soğuğu sıcak gibi algılamamız ya da gözümüzün yanılması renklerin, yok diyorum hiç bir zaman doğru gözlem yapmış olamam diyordum ama daha sonra diğerlerini de öğrendikten sonra bilimin doğası ile ilgili şeyler, ya hem benden kaynaklanan hem önyargılarımla alakalı olabilir hem deneyle alakalı olabilir o kadar çok hata olabilir ki ya da değişme payı var ki, yani veriler yeni şeyleri değiştirebilir ya bilimsel bilginin hiç bir zaman kesin olmadığını biliyorum

Table G.7 (continued)

		ki, imkansız yani, 5 işaretlemesi çok komik olur. Hatta 4 bile işaretlenmeyebilir ama ben çoğu kez o deney çerçevesinde doğru şeyler yaptığımı düşünüyorum işte olası tüm gözlemlere yer verip mantıklı çıkarım yapmaya çalıştığımı düşündüğüm için o yüzden genelde 4 3 işaretliyordum ama bazen mesela beynim duruyor çok yorum yapamıyorum ya da ne bileyim ön bilgim olmuyor o zaman çok daha düşük işaretliyorum çünkü kendime hiç güvenmiyorum elde ettiğim bulguyla ilgili. • I have been regretted not being very interested in the concept maps. Because concept maps had a lot of advantages. One of the advantage for example, misconceptions could be detected. To be able to make a summarization to students, it could be given students. When we created concept maps, our knowledge was more permanent. It also may be a technique to study exams. I could see on this map what I knew and what I could present. It was just a wonderful summary because it showed what I learned in the course. Even I could make evaluation on my learning that what I should have also included to my map. Instead of examining all manual, examining the last question could give clue about what every individual learned. Ben mesela bu kavram haritalarının üzerine çok düşemediğimden çok pişman oldum çünkü o kadar farklı şeyler söylüyor ki bir kavram haritasının avantajları dezavantajları diye böyle sıralamış dezavantajı yok zaten. Avantaj kısmına bir kavram yanılgıları bir de tanımları kullanabilir. Öğrencinin kafasında hani artık son bir özet oluşturmak için ya da kendin şey yapabiliyorsun, ben kendim oluşturduğum için onu ürettiğim için kesinlikle çok daha akılda kalıcı bir şey. Keşke bastan kavram haritasının tam olarak ne olduğunu böyle tam anlasaydım da ben kendim demekti çok üzerinde durmadım, tam anlasaydım da amaca uygun böyle daha çok yani çünkü orda şey yapıcım aslında, bir çeşit sınav çalışma yöntemi bile olabilir yani ne öğrenmişim ne çizebiliyorum ortaya ne koyabiliyorum, o kadar güzel bir özet ki, hatta şey değil bilgilerin değil de benim ne öğrendiğimin bir özeti olduğu için kendim sonra karsılaştırıp a laboratuarda su vardı ama ben hiç bunları dahil etmemişim haritama simdi fark ettim mesela. Gayet güzel ve yani öğrenciye çok kalıcı bilgi bırakabilecek bir şey ve şey neyi yanlış bilip neyi yanlış anladığını buradan özetle görebiliriz. Tüm föyü incelemek yerine burası çok daha faydalı olabilir.

Table G.7 (continued)

		• I have been trusted my self in both learning and teaching in science because I know how to give my knowledge to students and which information to give them. I do not see a reason for not trusting myself now. Bilgilerimi ne amac icin kulalnacagımı, cocuklara nasıl yansıtacagımı biliyorum bu nedenle de kendime guvenmemem icin hic bir sebep yok artık daha iyi daha fazla guveniyorum kendime. • Now I have been thinking that judging people due to their knowledge level or their questions that they asked is ridiculous. Because subjectivity is such a wonderful thing that if it was not be, there would not be much diversity in science area, different jobs and thoughts. Therefore, I have been thinking in that course that subjectivity is an amazing thing. inanısından dolayı yargılamak sacma, bildiklerinden dolayı az biliyor cok biliyor, cahil degil, sacmalıyor sacma sorular uretiyor. ya o oyle yani subj o kadar guzel bir seyki, o oyle olmasaydı o kadar cok cesitlilik bu kadar farklılık bu kadar degisik ilgi alanları, degisik meslekler degisik bilim alanları hic biri olusmazdı bence o uzden subj gayet cok guzel bi sey bence. • Manuals were appropriate to understand what our preknowledge was for the related topic, what we wanted to learn and what we learned at the end of the lesson. When I came to this laboratory course, I became aware of my preknowledge and what I kearned at the end of the lesson. For example the manual asked me what I knew for theory and law. Then it presented me the difference in an activity as a concrete way. Then at the end of the lesson I draw a concept map for my learning . The manual made me apply all these things and it was an effient way to show us what we had known before the experiments, what we learned and how to evaluate ourselves. Therefore, I found the manual effective. Öğrenci önceden ne öğrenmiş, ne öğrenmek istiyor ne öğrendi ne öğrenebilir yani föyler kesinlikle buna o kadar uygundu ki, yani ben geliyorum, ne biliyormuşum, tamama bunları böyle sonra ne yaptık mesela ben şey diyordum teori kanun farklı ama ben diyordum bunu somut işte bir tane yasa ile şunla bunla bir

Table G.7 (continued)

		bakıyorum sonrasında böyle bir şey geliyor. yani sonunda kavram haritası çiziyorum ne öğrenmişim özet yapıyorum mesela ve bunu hepsini uygulanması gereken etkili bir şey olarak öğrettikleri için bence gayet etkiliydi o yüzden. • In the course, at the end of the question, both misconceptions could be detected and our learning could be summarized. The things that I could include into my concept maps were the permanent knowledge for me. Therefore, this part was very good to evaluate my own learnings. Laboratuarda son kısımdaki soruda hem kavram yanılgıları tespit edilebiliyor hem ne öğrenmişiz çok güzel özetliyor yani o kısma neler koyabildiysem koyduğum her şeyi bilmiş güzel oturtmuşum demektir. Ve bu kısım kendimi değerlendirme açısından bu nedenle çok iyiydi. • For example every individual's values in the course were very different regarding to education background, family value, our belief and our interests. Therefore, I noticed that judging a person due to his/her subjectivity was a stupid behavior. Mesela getirdiğimiz değerlerimiz çok farklı eğitim alanlarımız, ilgilerimiz çok farklı, ailelerimiz çok farklı inandıklarımız çok farklı, o kadar farklı ki, artık mesela insanı sübjektif değerlerinden dolayı yargılamanın ne kadar aptalca ve sacmca bir şey olduğunun farkına varıyorsun.
METACOGNITIVE SKILLS	**Planning**	
	Monitoring	• Our learning styles were very different. While making observations and inferences, there was also a diversity in the group. Although we were all pre service science theachers and almost took the same academic lessons and had the same academic background, our learning style to learn these things were very different from each other. For example we were designing an experiment, every

Table G.7 (continued)

		member gave different ideas. Everybody made a different hypothesis. For example Didem thought in different way, Ela gave different ideas and I had totally different thought for the hypothesis or for the model. It was amazing. But sometimes we know very limited things and we were stuck in the same step. I noticed that even if we found a same result, our individual way to go this result was different most times. The thing I most like in this course was that you wondered how we obtained the result how we learn knowledge in the course. For example, you expect me to distinguish theory and law and you interested in how I reached this result, you wondered whether I had known anything related to it and whether I had had misconceptions for it. These things were very good in the laboratory course. Öğrenme şekillerimiz o kadar farklı ki. Gözlem yaparken farklılık vardı, çıkarım yaparken farklılık vardı şimdi tamam hepimiz fen bil. Öğretmenliği okuyoruz üç aşağı beş yukarı birçok konuyla ilgili temel bilgilerimiz aynı en azından bize verildiği kadarıyla. Ama onu bile öğrenme şekillerimiz o kadar farklıymış ki, bir şey oluyor benim aklıma ilk başka bir şey geliyor, onun başka bir şey geliyor yada ne bileyim hipotez kuracak oluyoruz onlar çok farklı düşünüyor o yada duyguyu örnek verdim ondan gideyim mesela, o çok farklı düşünüyor ben çok farklı düşünüyorum bazen hani o kadar sınırlı şey biliyoruz ki, bir bakıyoruz ki tık tık aynı yerde kaldık mesela, aynı şeyi düşünüyoruz o da öyle çok olası durumlarda oldu yani bence hani şeyleri çok fark ettim ben ya, mesela yapmışız bir şeyler herkes kendini bir şekilde ifade etmiş ama çok farklı yani. bence bir şeyi olayı bilmek değil burada da zaten benim en çok hoşuma giden bir şey bilip bilmediğimi test etmiyor ya ona nasıl ulaşıyorum ben o bilgiye mesela tamam teori ile kanunun birbirinden farklı şeyler olduğuna ulamsam bekleniyor benden ona nasıl ulaştığımla ilgileniyorsunuz ulaştım mı ulaşmadım mı, bunla ilgili önceden bir şey biliyor muydum bilmiyor muydum değil yani çok farklı yollarla yani aynı şeyi kavram yanılgılarını giderip aynı şeyleri öğrenebiliyoruz o da çok güzeldi bence laboratuarda. • I had only interested in the knowledge part of the science. I had not been aware of that how knowledge was obtained, how it was changed and the subjectivity feature. I had considered that scientist worked under rigid rules and they were objective in their studies. Therefore I had thought that science was made up of published knowledge in the books.

Table G.7 (continued)

		Bilimle ilgili ben sadece bilgi kısmıyla bilgi nasıl elde edilirmiş, değişirmiş değişmezmiş işte kişiden kişiye göre değişmesi, zamanla değişmesi, bunun hiç biriyle ilgili bilgim yoktu. Sanki bilim adamları katı kurallar çerçevesinde çalışmalar yapar herkesçe kabul edilmiş genel geçer bir doğru olur ondan sonra kitaplara falan girer yani bilimin sadece yayınlanmış kısmıyla hani şey ya makalelerle yayınlanmış ya da kitaplara girmiş bu şekilde sadece bilgiden ibaret olduğunu düşünüyordum hani elde edilmesiyle ilgili hiç bir bilgim yoktu. • I mostly learned during the experiments and discussions, whereas another member in the group could not learn in the experiment part instead our group discussion or designing procedure. Althiugh the experiments were very well designed for the targeted NOS aspect, some friends did not integrate NOS aspects to the experiment whereas some of us did. Daha çok deney esnasında öğreniyorum bir de tartışmalarda öğreniyorum ama kimisi de iste direk bilgiyle öğreniyor ne bileyim kendi aramızda şey yaptıklarımızla öğreniyor deney kısmında çok fazla şey kapmayan da var mesela hani direk o bilgiyi oraya entegre etmeyen de var. deney deney olarak kalıyor bilgi bilgi olarak kalıyor ama ben daha çok deneylerle öğrendim çünkü deneyler o kadar güzel seçilmiş ki, objektif ne ise, hangi NOS boyutları vurgulanacaksa deney ona cuk diye oturmuş o kadar güzeldi. • While I was learning something, I liked connecting knowledge with physics, chemistry and biology. While explaining my results or designing models I tried to connect my physics knowledge with chemistry or biology. Bir şeyler öğrenirken bağlantılar kurmak hoşuma gidiyor. Mesela öğrendiklerimi fizikle kimya ve biyoloji ile bağdaştırmaktan hoşlanıyorum. Sonuçlarımı açıklarken ya da model çizim ederken fizik bilgimi kimya ya da biyoloji ile bağdaştırmaya çalışıyorum. • I realized that I had some misconceptions for example in the light topic, I reorganized my knowledge because I had known a lot of things wrong. In addition, I have reorganized my knowledge regarding to NOS in the topics we have met in this course. I noticed that learning

Table G.7 (continued)

		topics according to nature of science was really different and I wanted to reorganize my all knowledge again by considering NOS. But I know that it is difficult. Işık konusunda kavram yanılgılarım olduğunu fark ettim. Bilgilerimi yeniden organize ettim çünkü pek çok şeyi yanlış biliyordum. Buna ilaveten laboratuarda öğrendiklerimi bir de NOS boyutlarını da göz önünde bulundurarak yeniden organize etme yoluna gittim. Konuları NOS'u düşünerek öğrenmek o kadar farklı ki, bütün bildiklerimi NOS'u da düşünerek yeniden organize etmek istedim ama biliyorum ki bu çok zor. • In our other lessons, it was expected from us to write the same things. For example hypothesis. The lecturer wanted us to write the same hypothesis. But in this course, it depended on me and there were a lot of alternative hypotehsis I could write. It depended on my creativity and multidimensional thinking. I had my data and hypothesis and I was free to express my thought. Çoğu derste öyle oluyordu şey veriliyordu bilgi veriliyordu da daha önceden de hipotezle ilgili birçok şey öğrendiğimiz için yanlış falan. Konu ne hipotez, tek bir hipotez var hoca doğru yada yanlış diyecek zaten orda ya tik atacak sınav kâğıdında ona ya da hayır. ve hepimizin hipotezleri aynı olmak zorunda. Ben burada bakıyorum konuya bir şeyleri test edeceğim orda gerçekten yazabileceğim alternatif bir suru hipotez var yani benim hangi yönü düşüneceğim bana kalmış biraz yaratıcılığıma kalmış ve bence orda çok yönlü düşünmeme kalmış hani böyle bakıyorsun verilerin her şey elinde yazabileceğin hipotez bence biraz daha çok yönlü düşünmenin bir urunu. • Sometimes I could write various hypothesis and there were times that I could write only one hypotesis. But when we came to group question, I heard very different hyothesis from my group friends and I told myself that why I could not think this. It was amazing. Then we decided on our group hypothesis among our individual hypothesis which made us satisfied or we made a new hypothesis while discussing in the group. Communication in the lesson was very good. I really thought sometimes that I was perfect. I told myself that I made all observations, collected my data and made a perfect hypothesis. But then one of my group friend thought a better thing and I was

Table G.7 (continued)

		surprised. I thought at that moment that how she thought this . Thinking firstly individually and as a group was very good. Bazen iki üç hipotez geliyor aklıma beğendiğimi yazıyorum yada bazen hiç gelmeyebiliyor tek bir tane yazıyorum. sonra gruba geldiğimiz zaman o kadar enteresan bir şey duyuyorum ki mesela gülsüm şey dikiyor böyle böyle diyor. aaa diyorum nasıl aklıma gelmedi böyle bir şey sonra ne yapıyoruz grup hipotezini bize en çok hepimizi tatmin eden daha böyle yapabileceğimiz falan değiştiriyorduk ve bir dersin içinde hem iletişim becerileri sayesinde bilmiyorum çok daha farklı ya bazen de hepimizin hipotezinin aynı çıktığı aynı şeyi düşündüğümüz de oluyordu çünkü çok fazla bilmiyor olabilirdik, o anda öyle denk geliyor olabilirdi böyle olduğu ama gerçekten kendimin mesela kendimi mükemmel zannediyorum diyorum ki tamam diyorum her şeyi gözlemledim tamam datalarımı topladım tas gibi de hipotez kurdum bir şey geliyor karsıdan nakout kalıyorsun orda ne kadar güzel bir şey aklına gelmiş diyorum benim aklıma gelmemişti mesela o acıdan çok güzel oldu yani önce bireysel yapıp sonra grup yapmak sonra bazen grup yapıp sonra ayrılmak çok güzeldi yani. • I realized that every problem I met had a solution. For example I had been panic about pronblems that I met in my daily life. But I have been thinking now that if I cause a problem, it ust have a solution. If I can not solve the problem, I may not see the solution. When I can not see, I ask help from a friend that I think s/he can see what I can not see. I really realized this situation in this course. My friends sometimes thought something that I did not think. Karşılaştığım problemlerin hep bir çözümünün olduğunu fark ettim. mesela bir problem, günlük hayatta da karsılaştığım mesela eyvah ne yapacağım falan olmuyor artık bende hocam. mesela bir şeyi çözmenin bir yolu vardır diyorum mesela buna ben sebep olduysam bunu halledebilirim diyorum bir yolu vardır ama ben göremiyorumdur diyorum ve çok farklı yaklaşmaya başladım mesela oda arkadaşım melek, melek diyorum mesela ben suna bakıyorum ama kor muyum diyorum algılamıyorum bunda bir gariplik var. şunu şunu goremiyorum. soruyorum. mesela kendimin goremeyip onun gorebilecegi seyler oldugunu dusunebiliyorum artık yani cok guzel bir sey bence.

Table G.7 (continued)

		• Discussions were useful in terms of evaluating myself. Because a friend told something and another answered with a different thought. Assisstants asked a question which could extend the discussion. There were very good questions that they helped me correct my mistakes and improved my learning. Tartışmalar benim kendi kendimi değerlendirmem bakımından iyi oluyordu. Çünkü tartışmaya başlıyoruz ve bir arkadaş bir şey soyluyor, başka bir arkadaş ona cevap olarak daha farklı bir şey soyluyor. Asistanlar farklı bir soru soruyor. O kadar güzel yönlendirici sorular vardı ki. Bu açıdan kendi kendimi düzeltme geliştirme açısından ve öğrenmelerimi kontrol etme açısından tartışmalar bana çok şey kattı. • At the beginning my trust to my knowledge in science decreased and I thought that I did not know much thing. Yes I did had theoretical knowledge but I had not known the tentativeness and subjective feature of science. Also I did not know how scientific knowledge was attained. My view to scientific knowledge has changed. Then learning the feature of scientific knowledge provided me more confidence in learning science. I realized that I both knew much thing and did not know much thing. And that was a part of nature of science. basta bir ilk guven sarsılması yasadım nasıl yasadım zaten hic bi sey bilmiyormussun ya biliyormuşsun tamam teorik bilgi çok biliyorsun ama nerden geldi bu napıyorsun yada o bilgiye bakış acım onu yorumlamam o kadar farklıymış ki, yani o çok değişti basta güvenle ilgili bir sarsıntı yasadım ama su an hani o en bastaki o güven halinden çok daha iyi bir yerdeyim. kendime daha fazla güveniyorum neden çok şey bilmiyormuşum, iyi kotu pek çok şey öğrendim bir de artık bunu da bilimin bir parçası olarak görüyorum yani su anda benim bunları biliyor olmam her şey yapabileceklerim ölçüsünde ya ben zaten yapabildiğim kadarını yapacağım ve o yüzden kendime çok güveniyorum kendime güvenmemek için bir sebep yok.

Table G.7 (continued)

	Evaluation	• Learning nature of science has changed my attitude towards philiosophy, religion, scientific knowledge , dailiy life and emotional feelings that subjectivity, creativity, socio cultural variables are all effect these things. Bilimin doğasını öğrenmem felsefeye, dine, bilimsel bilgiye, günlük yasama ve duygulara karsı tutumumu değiştirdi. Öyle ki, öznellik, yaratıcılık, sosyo kültürel değişkenlerin hepsi bunları etkiliyormuş. • Discussions were useful in terms of evaluating myself. Because a friend told something and another answered with a different thought. Assisstants asked a question which could extend the discussion. There were very good questions that they helped me correct my mistakes and improved my learning. Tartışmalar benim kendi kendimi değerlendirmem bakımından iyi oluyordu. Çünkü tartışmaya başlıyoruz ve bir arkadaş bir şey soyluyor, başka bir arkadaş ona cevap olarak daha farklı bir şey soyluyor. Asistanlar farklı biç soru soruyor. O kadar güzel yönlendirici sorular vardaki. Bu acıdan kendi kendimi düzeltme geliştirme açısından ve öğrenmelerimi kontrol etme açısından tartışmalar bana çok şey kattı. • I had supposed that I only learned theoretical knowledge. However I learned a lot of thing regarding to NOS. Ben burada sadece sığ bilgi öğreneceğiz zannettim. O kadar yanılıyormuşum. O kadar çok şey öğrendim ki bilimin farklı yönlerine dair. • Questions in the manual taught me ask critical questions. Foylerdeki sorular aslında bana eleştirel soru sormayı öğretti.

Table G.7 (continued)

		• Generally I was unsuccessful in the last question in the manual. Sometimes I took my feedback late from you. I wish I could have been taken my feedback in time. Maybe if I did it, I would have been more successful and developed my concept map and diagram. Genel anlamda bu derste son soruda başarısız olduğum oluyordu. Bazen foylerime çok geç bakıyordum keşke sizden dönütlerimi daha erken alsaymışım diyorum o zaman kavram haritaları ve diyagramlarımı daha çok geliştirebilirdim.