COGNITIVE ANALYSIS OF EXPERTS' AND NOVICES' CONCEPT MAPPING PROCESSES

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ABSTRACT

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In this study, Concept map (CM) development processes of the experts and novices were explored. This study aimed to investigate the similarities and differences among novices and experts' CM development process regarding their cognitive processes. Two experiments were designed; eye-tracking, written and verbal data were collected from 29 pre-service teachers and 6 subject matter experts. Data were analyzed by using qualitative and quantitative data analysis methods. The results indicated that even though some of the strategies were similar, there were different patterns followed by the experts and novices during the CM development process. Both experts and novices embraced 'deductive reasoning', and preferred 'hierarchical' type of CMs. The other patterns recognized during the process were 'filling information in an order', 'branch construction pattern', 'content richness' and 'progress pattern'. Novices and experts were distinguished in their content richness measures which used to determine the quality of the maps. Regarding the progress pattern, novices and experts differed in terms of the frequency and duration for specific acts in various phases of their progress in CM development process.

Furthermore, expert participants differed from novices in their fixation count numbers, fixation durations, visit duration periods for specific actions. Fixation count numbers of the novices were higher than the experts during the entire process and in specific dimensions of the CM development process. As a conclusion, these pattern differences affect the CM development process directly and the instructors need to give emphasis to these critical points while using CM during the instruction, and with the help of these pattern differences, instructors could guide the learner effectively and acquire content rich CMs.

Keywords: Eye movements, cognitive process, concept map, eye tracking

ÖZ

UZMAN VE DENEYİMSİZ KULLANICILARIN KAVRAM HARİTASI OLUŞTURMA SÜREÇLERİNİN BİLİŞSEL ANALİZİ

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Bu çalışmanın amacı uzman veya deneyimsiz katılımcıların kavram haritası oluşturma süreçlerini incelemektir. Uzman veya deneyimsiz katılımcıların kavram haritası oluşturma süreçlerindeki benzerlik ve farklılıklarını bilişsel süreçler açısından ortaya koymak amaçlanmaktadır. İki grup arasındaki farklılık ve benzerlikleri ortaya çıkarabilmek için 2 deney tasarlanmıştır. Deneyimsiz deney grubu olarak 29 öğretmen adayı ve uzman deney grubu olarak 6 alan uzmanı çalışmaya katılmıştır. Kullanıcılar arasındaki davranış kalıplarını araştırma amacıyla göz hareketlerine dayalı verinin yanı sıra yazılı ve sözel veri toplanmıştır. Kullanıcılardan toplanan veriler nitel ve nicel veri analiz yöntemleri kullanılarak çözümlenmiştir. Bulgular uzman ve deneyimsiz kullanıcıların kavram haritası oluşturma sürecinde farklı kalıpları benimsediklerini ortaya koymaktadır. Uzman ve deneyimsiz kullanıcıların genel olarak tümdengelimli akıl yürütme biçimini benimsedikleri ve hiyerarşik kavram haritalarını tercih ettikleri gözlemlenmiştir. Süreç içerisinde gözlemlenen diğer kalıplar sırasıyla; 'bilginin yerleştirilme sırası', ‘dallandırma’, ‘içerik zenginliği’ ve ‘gelişim modeli” olarak bulunmuştur. Kavram haritasının kalitesini belirlemede kullanılan içerik zenginliği ölçütleri açısından deneyimsiz ve uzman kullanıcılar farklılıklar göstermiştir. Gelişim modeli bağlamında, belirli hareketleri farklı periyotlarda gösterme sıklığı ve süreleri açısından deneyimsiz ve uzman kullanıcıların farklılıklar gösterdiği görülmüştür. Bunun yanı sıra, uzman ve deneyimsiz kullanıcıların ortalama odaklanma süresi, odaklanma sayısı ve toplam geçirilen süre açısından farklılıklar gösterdiği görülmüştür. Deneyimsiz kullanıcıların sürecin genelinde ve belirlenen hareketler açısından daha fazla odaklanma sayısına sahip oldukları belirlenmiştir. Sonuç olarak, ortaya çıkarılan bu davranış örüntüleri arasındaki farklılıklar kavram haritası oluşturma süreçlerini doğrudan etkilemektedir. Bu bakımdan öğretmenlerin kavram haritası kullanırken çalışmada ortaya çıkarılan bu noktalara önem vermeleri gerekmektedir. Bunun yanı sıra davranış örüntüleri arasındaki bu farklılıklar bağlamında öğretmenler öğrencileri uygun zamanlarda ve etkili bir şekilde yönlendirebilecekler ve içerik açısından daha zengin kavram haritaları elde edebileceklerdir.

Anahtar Sözcükler: Göz hareketleri, bilişsel süreçler, kavram haritası, göz izleme

To My Father, Mother

& Sister

who gave an unconditional love and encouragement through this dissertation and in my life

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TABLE OF CONTENTS

LIST OF TABLES

TABLES

LIST OF FIGURES

FIGURES

CHAPTER 1

INTRODUCTION

"I cannot teach anybody anything; I can only make them think…"
Socrates

In this chapter, the background of the study, the purpose and the significance of the study will be presented. The definition of terms and the abbreviations which are used frequently in the study are also listed in this chapter.

1.1. Background of the Study

Exploring the learning process is still a complex procedure for many researchers. Many research studies have been conducted on how learning occurs, which factors directly affect learning and how learning could be facilitated. Up to this point, there have been many different views on human learning. Yet, many of these views are focused on three main views; behaviorist, cognitivist and constructivist approaches. Behaviorism appeared in the first half of the 20^{th} century and leans on the idea of learning being interconnected with the stimulus and response and depends on observable behavior. In 1950s, the cognitive approach arose and introduced the idea that learning may occur by sending new information to the long term memory. Although behaviorism does not take the mental process in mind into consideration, the common point in both approaches is that they both assume the learner is a passive receiver of information. Following this, constructivism arose after the 1980s and suggested a different view on learning as learning. In this approach learning can occur only by constructing knowledge by learner's own. The main difference in this view is that it focuses on the learner as an active participator to the process and responsible from their own learning instead of a passive information receiver. This shift brought a change in our views on both learning and teaching, since the image of the learner as passive receiver of the information changed itself into an active knowledge constructer. Consequently, constructivism not only changes our thinking on the learning process itself but also the perceptions of the learner while considering the learning environment and tools.

In recent years, there is a growing interest in the active role of the learner. Learning strategies also gained attention among researchers after the adaptation process from behaviorism to cognitive theories. According to Weinstein and Mayer (1986), learning strategies aimed to affect the learners' encoding process. The change in the view also changed the appreciation of teaching-learning process. The activities and strategies were affected from this change as teachers' freedom of choice on presenting the information shifted to learners' actively elaborating and arranging (Weinstein & Mayer, 1986).

As the "active role of the learner" attracted the attention of many researchers, many tools and strategies started to be explored to determine their effectiveness and values. Concept maps (CM) are tools that are derived from the cognitivist approach have been valued among researchers and practitioners for a long time. The effects and benefits were examined in many research studies. CMs are considered as beneficial tools because of their structure represent the verbal knowledge visually. Novak and Canas (2008) explained Ausebel's basic idea on cognitive psychology on the learning process as "learning takes place by the assimilation of new concepts and propositions into existing concept and propositional frameworks held by the learner" (p.3). According to them this knowledge can be seen as the cognitive structure of individuals. For this reason, CMs are a good way to represent knowledge of the learner in order to comprehend the conceptual understanding of the learner (Novak & Canas, 2008).

In science education, teaching abstract concepts is a common challenge among educators. The most common problem that is encountered during this process is related to the misconceptions regarding "abstract concepts". According to Kinchin and Hay (2000), structuring of CMs is beneficial metacognitive tool that enhances the understanding and promotes chances to establish relations with existing structure and new knowledge in science education. CMs have been also used in science education, for evaluating the knowledge organization (Rice, Ryan & Samson, 1998, Ruiz- Primo & Shavelson, 1996; White & Gunstone, 1992). The importance of concept mapping in terms of the role in the process of demonstrating the individual perceptions on the subject, more willingly than copying the memorized facts, is emphasized by Jonassen, Reeves, Hong, Harvey and Peters (1997). Kinchin and Hay (2000) stressed the uniqueness of every map which is the key point in concept mapping, since every individual construct his/her map depending on their comprehension of content and the knowledge they acquired.

Furthermore, organization of knowledge is critical in order to comprehend a specific subject area in science education (e.g., Novak, 1990). CMs are considered as a good way for representing the organization of the knowledge of students and could help them in the process of knowledge organization (Novak & Gowin, 1984; Mintzes, Wandersee & Novak, 1998). According to Mintzes, Wandersee and Novak (1998), it is required to grasp the meaning of concepts and use them in a scientific way during the concept mapping process. They also add the necessity of emphasized and careful concept usage to be expressed during the concept mapping process (Mintzes, Wandersee & Novak, 1998). Novak and Canas (2008) highlighted the power of concept mapping as its potential to facilitate the meaningful learning and provide "a kind of template or scaffold to help to organize knowledge and to structure it, even though the structure must be built up piece by piece with small units of interacting concept and propositional frameworks" (p.7). CMs are considered a beneficial tool for teachers since it enables them to identify the ways of organizing meanings and discussing these meanings with students while showing the students' misconceptions (e.g. Novak & Gowin, 1984), and it provides "a metacognitive tool to help learners reorganize their cognitive frameworks into more powerful integrated patterns" (Mintzes et al., 1998, p. 115).

In recent years, CMs have started to be used in many fields and for diverse purposes. The common usages of CMs in teaching are; using filling maps (Ruiz-Primo, Shultz, Li & Shavelson, 1998), using CMs as assessment tools while considering the issue of reliability and validity (Ruiz-Primo & Shavelson, 1996), using different linking phrases in concept mapping (Yin, Vanides, Ruiz-Primo, Ayala, & Shavelson, 2004) and investigating the feasibility of online CMs (Herl, O'Neil, Chung, Dennis & Lee, 1997). CMs are commonly explored in various areas. The frequently explored characteristics of CMs were their hierarchical structure, cross-links among branches as well as specific examples related with the maps.

In the investigated literature, there are also many studies indicating that pencil and paper is a common way of developing CMs; however this is not very effective for learners and teachers. In recent years, the trend changed into using computer based software for developing CMs. The reasons behind the decision for the preferring computer based concept mapping arethe cost effectiveness of converting the paper and pencil maps to computerized format, issues of practicality while working with large group of people and the potential for missing data. In addition to these problems, there is a higher chance of missing data than the researcher may expect in paper and pencil concept maps (Herl, O'Neil, Chung, Dennis & Lee, 1997). There is also the issue of the quality of the CMs that may vary from one creator to the next (Herl, O'Neil, Chung, Dennis & Lee, 1997). The end product which is constructed by paper and pencil included many revisions which prevent the ability to see the whole picture by examining the process. Therefore, the development process could not be explored and conclusions could not be drawn regarding the process itself. In order to see the whole picture, the end product is essential but the process needs to embrace the weak points of the learners and their misconceptions.

As discussed above, concept maps' potential for representing the verbal knowledge visually is apparent. Since constructivism emphasizes the importance of knowledge construction of the learner and concentrates on the active participation in this process, CMs are valuable tools that implement knowledge construction effectively. Eventhough the emphasis is more on the learner than the instructor; the assessment is still a problem. Link and cross-link number is a well-known and still being used method for using CMs as assessment tools and considering them in scoring the concept. In this process some of the researchers proposed some techniques which depend on counting the number of the links, concepts or cross links. However, exploring the development process is critical; that it centralizes the learner and suits the constructivism's fundamentals. Although the process requires an assessment step to gather information on the process in terms of the quality of the maps, counting the concepts and relations in the content of maps may not be an effective strategy. Even if there are research studies in the literature focused on CMs emphasizing the development of maps, cognitive process of the learners during CM development is not a well-studied area among researchers, yet.

1.2 Purpose of the Study

The purpose of this study is to understand the CM development process from the perspectives of experts and novices. This study is not interested in just scoring the concepts and relations, instead it was focused on exploring the CM development process since this process includes much more than acquiring an end-product. During the CM development process, visual representation of information is the main focus; even though the individuals may use inappropriate concepts or links that may result with correct relations among the concepts in their map. The CM development process itself includes chain of cognitive processes in it, the activities like arranging, constructing, deleting or changing into another relation or concept are also related with construction process and this needs to be explored in detail. At this point, exploring the CM development process becomes a critical issue that includes representing the existing knowledge visually by forming relations among concepts and using links. This process is also crucial for determining the reasons of ineffective CM usage and also the deficiencies of the learners are explored more easily and effectively by considering the reasons lying beneath.

Moreover, it was aimed to explore whether there are patterns among novices and experts' CM development processes regarding their cognitive processes. In order to determine the patterns among novices and experts, the entire process was explored by focusing on a case. Specifically, explicit similarities or differences among the novices and experts will be determined. Exploring the cognitive dimension of CM development process will give chance to see the differences and range between individuals in terms of their expertise and how it affects the map development directly. While determining the differences among experts and novices, giving essential support to the learners at the right time will be possible. To give the essential support to the learners at the right time is another concern for this study. Furthermore, with this study practitioners will provide practical suggestions and strategies to the novices about how an efficient CM could be developed.

1.3 Research Questions

Throughout this study, answers of the following questions were investigated. Also, in order to answer the main research question the sub questions were investigated.

The Main Research Question

- How do novices and experts establish their concept mapping processes?

Sub questions:

1. Do novices and experts use specific strategies during the concept map development process?
2. How does concept map development processes differ within novices and experts?
    2.1 Are there differences between novice and expert participants in terms of their eye behavior (e.g. fixation count, visit duration and fixation duration)?
    2.2 Is there any difference among experts' and novices' concept maps in terms of content richness?
3. What are the factors that affect concept map development process?

1. 4 Significance of the Study

Evaluation of the information constructed by students is still a problematic issue for teachers since standard assessment tools were not capable of evaluating in constructivist approach. This was supported by Mintzes, Wandersee and Novak (1998) as they pointed out the suitability of concept maps to constructivist perspectives. They stated the total process includes the perspectıve of the mapper during development of the map and the product would be a result of his/her own knowledge structure which could be finalized individually or collaboratively. As CMs are beneficial tools for representing existing knowledge visually and meaningfully rather than memorizing the facts and writing them down (Novak & Gowin, 1984), this approach enables students to analyze their existing knowledge while comparing them with the previous. In Turkey, the curriculum was re-constructed based on constructivist perspective and this change necessitated the exploration of the pre-service teachers' view and experiences on the usage of CMs. Exploring pre-service teachers' view is important to estimate the near future and applicability of these kinds of tools in practice.

Although concept mapping is a vastly researched area, not many have focused on the CM development process; instead they were directed to the potential of CMs in the assessment process and the evaluation of the CMs. This study aimed to explore pre-service teachers' who are considered as novices and domain experts' in the CM development process by using the eye-tracking device. The nature of the CM development process is not a well-studied issue for researchers especially considering the perspectives of the experts' and novices' by using eye behavior. This study is an important contribution to the field of education because it has the potential to contribute to these issues while introducing a combined perspective which integrates them under the same umbrella.

This study may also offer valuable information on the cognitive process of pre-service teachers during CM development and may help them to regulate the process of teaching while considering the differences between learners in terms of CM development patterns. It has a potential for suggesting practical contributions like helping novices to develop CMs effectively and adequately while gaining information about the process. This study may also help researchers comprehend their knowledge on CM development, expertise and cognitive process while considering the role of CMs in the learning process. Although this study was conducted in institution where the medium of instruction is in English, the practical suggestions for these kinds of diagrams could also be applicable for other teachers who teach in Turkish. The results of the study may also provide clues for increasing quality of the maps while considering the perspectives of the learners.

1.5 Definition of Terms

Expert: Person who has special knowledge and experience on a particular domain.
Novice: Novice is considered a person who is new to a field and has little experience on a selected subject.

Concept map: A diagram which enables representing the knowledge structure of the map developer while showing the concepts and relations among them.

Fixation: "Eye movements that stabilize the retina over a stationary object of interest" (Duchowski, 2003, p.46).

Fixation duration: The period in milliseconds that the eye fixation finished.

Fixation count: The number of eye fixations disseminated on a determined area.

Visit Duration: The duration of the fixations in seconds in a determined area.

Gaze plot: Static representation of the gaze data for each image of the stimuli to visualize the eye scan paths.

Heat map: A static view of the gaze behavior of the entire group of recordings which consist of a transparent background image with highlighted areas where the participant looked.

Saccades: Rapid eye movements from one fixation to another.

Scene: Eye movements coming from dynamic content required to be divided into scenes, which is a part of the recording, to make calculations of eye movement data. A scene can include more than one segment.

Segment: Part of the eye movement recording.

1.6 Abbreviations

CCT: Cell Concept Test

CM: Concept map

FD: Fixation Duration

FC: Fixation Count

HCI: Human Computer Interaction

MCT: Matter Concept Test

METU: Middle East Technical University

VD: Visit Duration

CHAPTER 2

LITERATURE REVIEW

This chapter introduces the related research studies on concept mapping and cognitive processes of human during the learning process. Concept mapping issue is discussed in detail from a cognitive dimension and expertise. Especially the function of concept mapping in education was highlighted. In addition, eye tracking studies related with the functions of concept mapping in the cognitive dimensions of learning with regard to expert and novice behavior were discussed.

2.1 Concept Mapping and Related Research Studies

The idea of concept mapping originated from Ausubel's studies on meaningful learning theory emphasizing the importance of prior knowledge and the effect of advance organizer on learning and retention (Ausubel, 1960, 1962; Ausubel & Fitzgerald, 1962). Ausebel (1963) explained his ideas in the light of the cognitive development process and he underlined the importance of assimilation theory. This theory stressed the importance of developing new ideas and meanings with the help of prior knowledge and relationships in mind (Ausebel, 1963). In the light of Ausubel's idea of meaningful learning, the necessity of prior knowledge is pointed out (Novak & Gowin, 1984).

Three conditions is required for meaningful learning; "the material itself must have potential meaning (i.e., rather than a list of nonsense syllables); the individual must possess a framework of relevant, domain-specific concepts to anchor the new knowledge; and the individual must choose voluntarily to incorporate new concepts in a nonarbitrary, nonverbatim fashion" (Pearsall, Skipper & Mintzes, 1997, p.195). In order to support the meaningful learning, evaluation strategies needed to be refined which relate the new ideas with the acquired knowledge (Novak & Canas, 2008). In this respect Ausubel, Novak and Hanesian (1978) explained the function of advance organizer as 'to provide ideational scaffolding for the stable incorporation and retention of more detailed and differentiated material that follows' (p.172). The purpose of the advance organizer was also articulated by Mayer (1979) as 'to provide ideational scaffolding for the stable incorporation and retention of the more detailed and differentiated material that follows' (Ausubel, 1968, p.148 cited in Mayer, 1979). The main idea underlying the advance organizers are highlighting the importance of previously learned information while grasping the new information while relating the similarities and distinctions according to cognitive structure. Many studies were conducted to determine the potential of advance organizer as a teaching strategy (Lawton & Wanska, 1977), positive effects on learning and retention (Luiten, Ames & Ackerson, 1980; Ausubel, 1960; Scandura & Wells, 1967). For the key ideas of Ausubel's assimilation theory see figure 2.1.

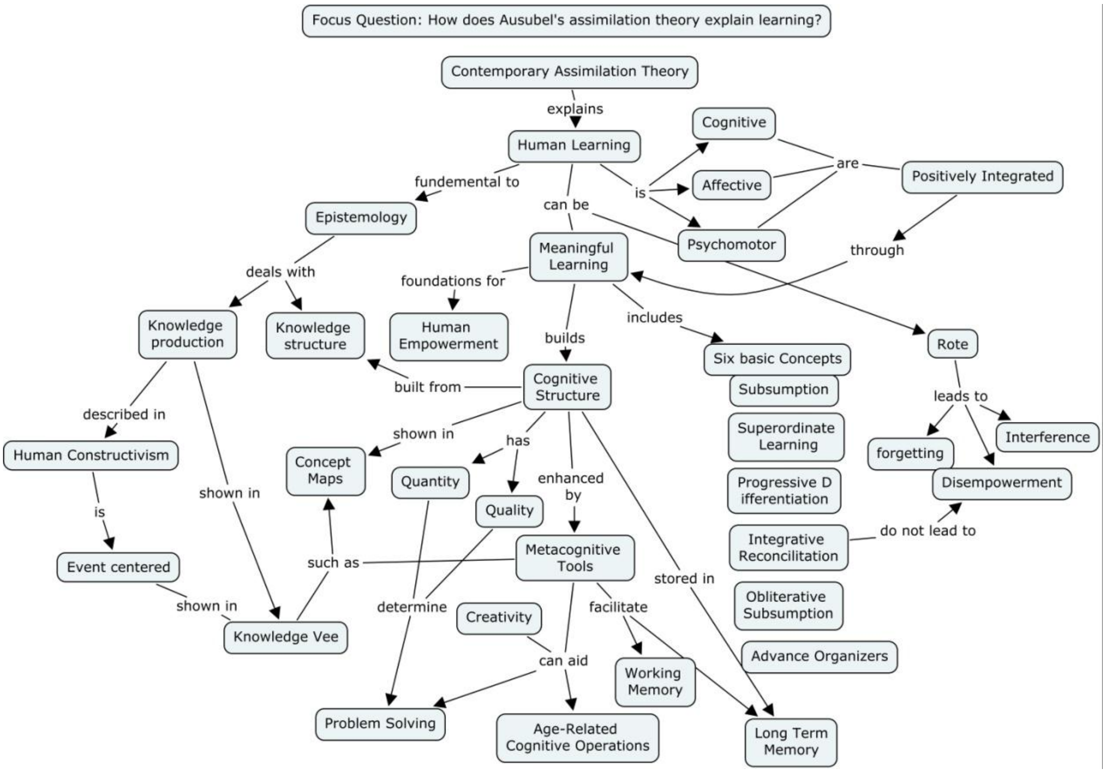


Figure 2.1 Key Ideas in Ausubel's Assimilation Theory Integrated with Key Ideas from Epistemology (Reprinted from Novak, 2010, p.58)

In the light of Ausubel's principles, Novak and Gowin (1984) introduced concept maps as an educational tool for embodying the meaningful relations among the concepts. CM has been identified by many authors in the literature. According to Novak and Gowin (1984); CM is defined as "a schematic device for representing a set of concept meanings embedded in a framework of propositions" (p.15). Its importance as a metacognitive tool in science education (Mintzes, Wandersee and Novak, 1997), and potential as a spatial demonstration of concept and connection for providing the knowledge structure in the mind (Jonassen, Beisser & Yacci, 1993). According to them, "memory structures (and by inference, structural knowledge) literally exist as representations in the mind that they represent not only behavior but also internal representational structures and mental processes" (Jonassen, Beissner & Yacci, 1993, p.11). Nesbit and Adesope (2006) stated CMs "are diagrams that represent ideas as node-link assemblies" (p. 413). They acknowledged that CMs provide a spatial representation of knowledge structures with concepts, and semantic relations between these concepts (Nesbit & Adesope, 2006).

In this respect, as an educational diagram, concept maps' have many benefits in educational studies. Novak and Gowin (1984) explained concept maps' potential as showing a blueprint for taking the advantages of associating concepts and propositions (Novak & Gowin, 1984). CMs can be also used as a tool for assessment purposes to evaluate what has been learned (Novak & Gowin, 1984), and for tracing the conceptual development process (Novak, 2005). In addition, they can enable people creating theoretical knowledge by arranging and uttering the existing information (Jonassen, 2000).

De Simone, Schmid and McEwan (2001) reported parallel results with this view. Their study revealed that concept mapping activity was seen as a beneficial process by students since it enables them to enable visual illustration of their existing knowledge. The potential of collaborative concept mapping was also expressed as a helpful way to understand and categorize the content. Larkin and Simon (1987) also mentioned the importance of using diagrams and picture in problem solving process while emphasizing the considerable usage of them in specific domains like physics and engineering. They also expressed the superiorities of diagrams in problem solving as its potentials to reduce the searching process, to enable grouping under a single concept, and the possibility of assisting "the perceptual inferences which are extremely easy for humans" (Larking & Simon, 1987, p. 98). For an example to show the characteristics of concept map from Novak's point of view, see figure 2.2.

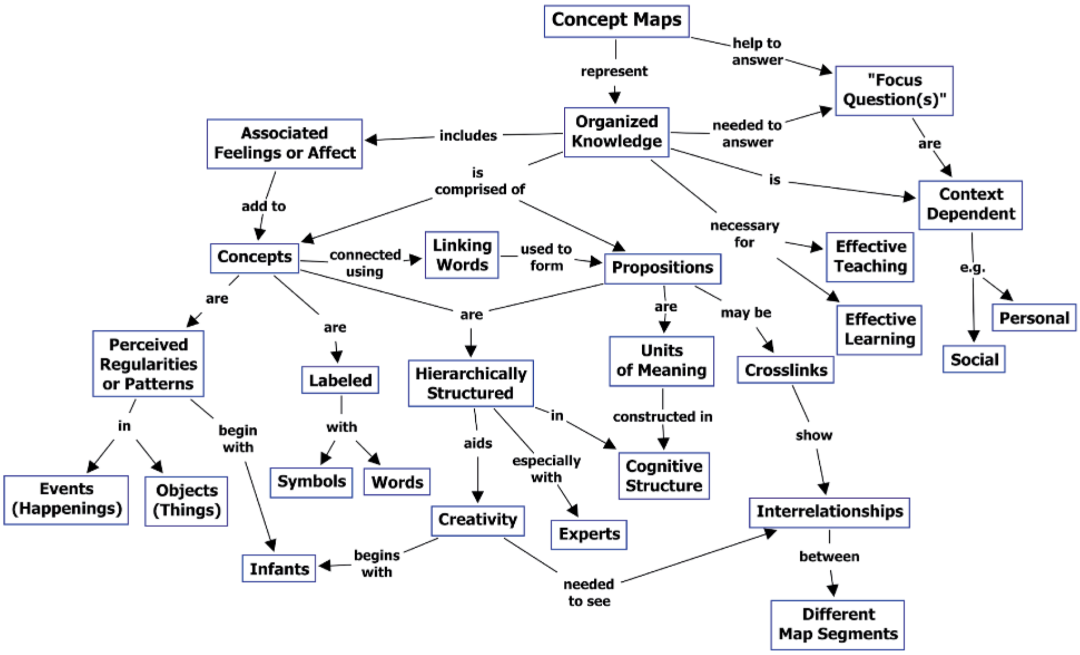


Figure 2.2 An Example of Concept Map to Show the Characteristics of Concept Map and How Novak Explain Them (Reprinted from Novak & Canas, 2008, p. 27)

The importance of CMs in terms of showing the learners' previous knowledge was also expressed by Ruiz-Primo, Shavelson, Li and Schultz (2001). Jonassen (2000) affiliate this idea and add a different view, he consider semantic networks are one of the mind tools which is defined as computerized device and learning setting altered for taking the attention of learners and assisting them through the critical thinking and complex problem solving process. According to Jonassen et al. (1993), mind tools as semantic networks characterizing structural knowledge associating the declarative and procedural knowledge. Structural knowledge defined as "the knowledge of how concepts within a domain are interrelated" (Diekhoff, 1983 cited in Jonassen et al, 1993). Structural knowledge also known as cognitive structure (Jonassen et al.,1993, p. 4) and this was remarked by Preece (1976) as 'the pattern of relationships among concepts in memory' (cited in Jonassen, 2000, p.1). The importance of the structural knowledge in problem solving process was also

indicated by Chi and Glaser (1985) In this respect, cognitive structure of the learners could be arranged by the assistance of semantic networks (Ruiz-Primo et al, 2001).
In the literature, there are remarkable research studies investigated CMs for different purposes. Most of the studies in the literature have focused on the practical applications of the CMs in education (Derbentseva, Safayeni and Canas**,** 2007). The effectiveness of concept mapping (Christianson & Fisher, 1999;Wallace & Mintzes, 1990) using CMs for supporting the students during science concept learning process (Alvares & Risko, 1987 cited in Elhelou, 1997) and using CMs and learning cycle for advancing the pupils understanding on Biology (Odom & Kelly, 2001) were some of the explored issues by researchers.

CMs and its role in assessment process are another aspect studied among researchers. Ruiz-Primo and Shavelson (1996) introduced the way of thinking CMs as an alternative assessment way. Many studies were conducted to investigate the role of CMs in assessment process; like using select and fill-in CMs (Schau, Mattern, Zeilik, Teague & Weber, 2001); giving expert maps for scaffolding the learner (O'Donnell, Dansereau & Hall, 2002), comparing different maps which were structured with constructing-a-map with created linking phrases, and constructing a map with selected linking phrases (Yin, Vanides, Ruiz-Primo, Ayala & Shavelson, 2004); using concept maps for assessing the prospective teachers' understanding on impulse-momentum topic while comparing CMs with achievement test (Ingec, 2009).

Other issues explored in the literature are using CMs as an evaluation method to determine the problems and solutions (Streeter, Franklin, Kim & Tripodi, 2011), authentic tool for self-assessment to determine the change on their conceptual understanding (Kaya, 2008), as a method to evaluate the understanding degree of the science achievement (Rice, Ryan & Samson, 1998); and employing computer-assisted CMs for assessment in pre-post test design and its benefits (Schaal, Bogner & Girwidz, 2010).

Additionally, Ruiz-Primo, Shavelson and Shultz (2001) used CMs in another study for assessment purpose by comparing three concept mapping technique; construct-a-map from scratch, fill-in-the-nodes, fill-in-the-lines" (p. 99). They explored the effectiveness of concept mapping by using talk-aloud protocols to determine the performance scores of the participants. Moreover, Howard and Barton (1986) highlighted the potential of the CM as regarding it as a way of "thinking on paper"; according to them CM enables us to see the indefinite relations and potential gaps in your thinking mechanism while showing the contradictions among your thoughts.

Investigating different cognitive process and prior knowledge activation with the aid of concept mapping is also examined by the researchers (Gurlitt, Renkl, Motes & Hauser, 2006). They conducted a study to explore the role of CMs as a supportive tool for stimulating the prior knowledge (Gurlitt, Renkl, Motes & Hauser, 2006). The results showed that using specific concept mapping tasks brought out differences in prior knowledge activation procedures and this is important for practical implications.

CMs have been used for many purposes in education and the early studies on the use of CMs in education have been carried out usually with paper and pencil. Though it was immensely used, there includes some problems like revising the map and adding new branches or concepts is considerably hard with paper and pencil. Also, from the teachers' point of view the evaluation process is extensively time consuming (Chui, Huang & Chang, 2000). These problems caused the need to use technology in the process of concept mapping, and various softwares were developed for this purpose. Structuring CMs with using computer based activities both effective for students and teachers enabling to handle the paper based concept mapping problems with the aid of computers' preferences.

Another study explored the students' CMs by using qualitative approach. Specifically three major patterns; 'spoke', 'chain' and 'net' structures were explored by representing the examples to the students. Concept mapping and its potential in collaborative groups for facilitating their conceptual change were recognized. The value of student generated maps were also highlighted (Kinchin, Hay & Adams, 2000). As it was observed in the literature, there were various attempts to discover the CMs and its potential for educational purposes. Particularly, the related studies investigated in Turkey were summarized to see the picture in Turkey.

2.1.1 Concept Mapping and the Attempts in Turkey

As the CMs can be used for many purposes in education, related studies were also conducted to benefit from its effectiveness in Turkey. Many studies are conducted in Turkey related with concept mapping and its effectiveness. Yavuz (2005) examined the understandings of seventh grade students on matter concept in conceptual change instruction companying with computer based concept mapping. The results showed that computer assisted concept mapping produced a better acquisition of the science understanding on matter concept and a more positive perspective was revealed toward science than the conventional science instruction. Kilic (2003) examined the effects of using CMs in Turkish and the problems related with the linguistic nature of Turkish language. The findings revealed that in order to show the relationships on CMs, adequate ways could be used in Turkish; like writing a complete sentence on the linking line, writing short paragraphs to clarify the relationships or using verbal explanations.

Moreover, the assessment potential of concept mapping compared to the achievement test (Ingec, 2009), introducing CM as a computer based assessment tool (Akkaya, Karakirik & Durmus, 2005) were some of the issues explored. Akdur (1996) examined another study to understand the effectiveness of collaborative concept mapping by using both computer and paper based settings. The results showed that participants' attitudes and views on collaborative concept mapping on computer to paper, the results showed that computer based concept mapping affected the students positively than the paper based and they consider CMs which is beneficial for metacognition and they also positive views on concept mapping via computer.

Furthermore, the effect of conceptual change texts with concept mapping on different science subjects was explored by many authors (Ozkan, Tekkaya, Geban, 2004; Tekkaya, 2003; Sungur, 2000; Yilmaz, 1998; Uzuntiryaki, 1998). Sungur (2000) explored the effect of conceptual change texts and concept mapping on their conception of human circulatory system and determine the misconceptions. The results showed that conceptual text and concept mapping made a considerable contribution to the understanding of human circulatory system of the students. Cell division unit and the effect of conceptual change text with concept mapping to find the misconceptions was another explored issue (Yilmaz, 1998). Students' Biology achievement and their attitudes toward the CM development process and their relation were also examined. The results were consistent with the previous studies as a significant contribution of contextual text with concept mapping. Furthermore, there was a positive relation between achievement and the attitudes towards CM development process. Another comparison study was conducted by Uzuntiryaki (1998) to investigate the participants' understanding on solution concept and attitude toward science while comparing the effectiveness of the conceptual text and concept mapping instruction. Considerably better acquisition of science understanding was found by using the conceptual text and concept mapping instruction together. In addition their attitudes towards science were notably higher than the conventional science instruction. To sum up, many of the studies in Turkey focused on relations between the conceptual change and CMs, determining and preventing misconceptions with the aid of CMs and the Turkish language effect on concept mapping process.

2.2 Expert and Novice Behavior

This section gives an overview about the nature of expertise and related studies investigating the behavior pattern of experts. The views of educators to the expert knowledge, becoming an expert and problem solving processes in experts and novices will be also covered under this section.

The nature of expertise and expert behavior has being researched for several years (Ericsson, 2009; Colins & Evans, 2007; Ericsson, Charness, Feltowich & Hoffman, 2006; Chi, Glaser & Farr, 1988). Who is an expert and who has been considered as an expert were the question in human beings' mind even in Socratic periods of the history as "whether a man is able to examine another man who claims to know something to see whether he does or not; Socrates wonders whether a man can distinguish someone who pretends to be a doctor from someone who really and truly is one (Charmides, 170d-e cited in Selinger & Crease, 2006). Despite the curiosity of understanding the mystery of being expert, a common view exist is that understanding what makes an expert would facilitate developing better training program (Bilalic, McLeod & Gobet, 2008). They also supported this view as, consideration of experts' problem solving approaches would aid to the acquisition of expertise (Bialic, McLeod & Gobet, 2008). In addition, several studies were conducted to explore the relation between expertise and problem solving process in the literature (Anderson, 1993; Koedinger & Anderson, 1990; Patel & Groen, 1991; Williams, Papierno, Makel & Ceci, 2004). The important role of understanding problem-solving strategies was also explored by many researchers (Anderson, 1993; Koedinger & Anderson, 1990; Patel & Groen, 1991; Williams, Papierno, Makel & Ceci, 2004).

Additionally, a well-known question comes to mind on why chess is a hard game for especially novices while focusing on the differences between the novices and experts. Medin, Ross and Markman (2005) explained the process as the representation of the board information is very complex" (p.422). They also emphasized that experts use a groups of chunks which includes many more pieces unlike novices (Medin, Ross & Markman, 2005). This view is also supported by Chase and Simon (1973) as the trick of the experts is that they arrange the pieces much better than the novices and it enables the increase in their performances (cited in Goldstein, 2005). In addition, the role of the practice in chess practice and the relation among the chess ability and the practice time were revealed (Campitelli & Gobet, 2008).

In a consequence of interest on this issue, various definitions emerged for expert and expertise in the literature. Expert is defined as "one with the special skill or knowledge representing mastery of particular subject" ("Encyclopedia Britannica", n.d) or 'someone widely recognized as reliable source of knowledge, technique, or skill whose judgment is accorded authority and status by the public or his or her peers' (Ericsson, Charness, Feltovich & Hoffman, 2006, p.3). Parallel to this definition, Ericsson et al. (2006) explained expertise as "the characteristics, skills, and the knowledge that distinguish experts from novices and less experienced people" (p.3). On the other hand, novice is defined as "a person who is just starting out in a field of activity" ("Encyclopedia Britannica", n.d).

The Views of Educators to the Expert Knowledge and Expertise

In the history, there are developments effected the views of educators on expertise. Amirault and Branson (2006) explained that there is a shift from individualized instruction in the ancient times to mass education and the transition in the model of 'education for few' to 'education for many' changed the views of educators on expertise. In addition, instructor position also changed between 'being subject matter expert and expert in educational techniques' (p.70). Moreover, in ancient times the dominancy of 'informal and oral assessment' left his place to 'formal, objective, and measurable assessment' (p.70). In the 20th century, the acquisition of expertise drew the attention of the cognitive psychologists trying to identify the inner factors responsible for facilitating the human performance.

Medin, Ross and Markman (2005) identified the common differences among expert and novice as, the capacity to store larger amount of information with establishing relations among them. According to Goldstein (2005), experts' knowledge is organized that they can attain the necessary information which is important in problem solving process as well as the amount of knowledge they possessed. Moreover, the knowledge organization of experts differs from novices; novices classify the problems in terms of their similarities of the objects whereas experts tend to classify the problems with considering the general principles (Goldstein, 2005). In terms of the time spent on task, experts are slower than the novices as they focused on comprehending the problem instead of attempting to find a solution. Although experts seems to spent much more time in problem solving process than the novices, this strategy yields with more effective results (Goldstein, 2005). According to Chi (2006); experts have some common outshining characteristics like;

- Generating the best: Experts usually generate the best solution or move for the problem.
- Detection and recognition: They can perceive the parts which could not be recognized by novices. Unlike the novices, experts could distinguish the "deeper structure of the problem or situation". (Chi & Feltovich, & Glaser, 1981).
- Qualitative analyses: Analyzing the problem qualitatively and providing a picture of the problem while including their field of expertise takes a great period of time. (Simon & Simon, 1978; Voss, Greene, Post, & Penner, 1983 cited in Chi, 2006).
- Monitoring: Experts' self-monitoring skills are very precise like finding the errors and perceiving their level of knowledge than novices,

- <u>Strategies:</u> In terms of selecting the suitable strategies experts are more efficient than the novices.
- <u>Opportunistic:</u> Experts are more opportunistic than novices; they make use of whatever sources of information are available while solving problems (Gilhooly et al., 1997 cited in Chi, 2006) and also exhibit more opportunism in using resources.
- <u>Cognitive effort:</u> The relevant knowledge and approaches could be recalled by experts without making a great cognitive effort as novices did (Alexandar, 2003 cited in Chi, 2006)

In the literature there are many research studies encompassing the expertise issue; like examining the coaching strategies for facilitating the students for practicing problem solving skills like experts in instructional design cases (Stepich, Ertmer & Lane, 2001), exploring the importance of expertise in complex cognitive tasks (Yeon Lee, 2002). Additionally, expert and novice comparison studies are also common among researchers (Ishii & Miwa, 2002; Carter, Sabers, Cushing, Pinnegar & Berliner, 1987, Fiske, Kinder & Larter, 1983; Law, Atkins, Kirkpatrick, Lomax & Mackenzie, 2004).

Another technique that widely used to diferentiate novices and experts is using eye movement (Van Gog, Paas & Merrienboer, 2005). Kasarskis et al. (2001) focused on the differences between novice and expert pilots in terms of the performance differences in a flight simulator. The findings supported the view on expert pilots are more successful than the novices and the time period is also shorter. The expert pilots are much more swiftly received the necessary information (cited in Law, Atkins, Kirkpatrick, Lomax & Mackenzie, 2004). In addition to this the eye tracking data showed that the fixation locations of the experts differ from novices. Experts are much more focused on the airspeed indicator and less fixated to the altimeter. It was understood that "the experts' fixation behavior is learned by their knowledge that the airspeed indicator was more informative" (Law et al., 2004, p.42). Jarodzka, Scheiter, Gerjets and Van Gog (2010) focused on the differences between experts and novices during a complicated visual stimulus. They gathered eye movement, verbal and performance data from both experts and novices. Directing to the relevant features of the stimuli and using varied ways and knowledge-based shortcuts are the observed behaviors for experts comparing to novices.

Another study that utilized eye tracking was conducted by Rosengrant, Thomson and Mzoughi (2009) to explore the differences between problem solving process of experts and novices during the electrical circuit problems. Eye tracking device was used to determine the differences and similarities during the problem solving process. Similarities between novices and experts were found in gaze patterns. In addition, experts have a recalling during the process and a checking behavior at the end whereas the novices do not have. Also, in the literature the common novice behavior is specified as novices are much more focused on what they see, more descriptive and their comprehension is not very deep (Kurland, Gertner, Bartee, Chisholm & McQuade, 2005). Erkent (2004) examined the expert and novice chess players' tactics with the aid of eye tracking and electrooculography technique. The results showed that experts generated more fixations than the novices. The strength of early perceptual encoding of experts is verified which could be ground for chess knowledge.

Problem Solving Processes among Experts and Novices

Similar to other issues, there are differences among experts and novices in problem solving processes. According to Gagne (1984) problem solving activity is defined as "a natural extension of both rule learning and schema learning. The solving of a problem guided the stored verbal knowledge possessed by the learner, which makes possible the interpretation of the problem" (p.178). He also emphasized the importance of connecting both the previously learned rules and yields with new learning. The necessity of cognitive strategies and a set of schemata are explained by Gagne (1984) while explaining the requirements during problem solving process. He also expressed schemata enable learner to associate the components of the problem. Jonassen (2011) also consider problem solving is “a cognitive process” (p.2). He also added effective problem solving process necessitate constructing mental models by representing their knowledge structures. It seems that problem solving is a mental process that people actively participate and presenting visual representation of the knowledge structure is important in this process (Jonassen, 2011).

CMs are beneficial tools for representing the knowledge structure visually. While developing concept maps, the learners could re-visualize the information with the aid of utilizing new propositions while improving the concepts from the prior knowledge. According to the research studies, “well-organized and integrated domain knowledge (as evidenced by integrated concept maps) is essential for problem solving. It is necessary to understand the conceptual relationships between the concepts in any problem domain in order to be able to transfer any problem-solving skills developed” (Jonassen, 2011, p.313). Presenting a problem includes two phases; comprehension and searching phases. The comprehension phase is considered as simple, the distinction between novices and experts could be judged by making comparisons in this searching phase (Chi, 2006). Many studies were conducted to explore the expert behavior and possible reasons of their success. The differences between expert and novice players were identified as in “the macro-structure of search” during the problem solving process (e.g. Bialic, McLeod & Gobet, 2008, p.401). Hegarty, Mayer & Monk (1995) conducted a study that compares successful and unsuccessful problem solvers in an arithmetic word problem. Eye fixations were compared during the problem solving process in terms of their fixations on either words or numbers. In addition, the retention of meaning and correct wording was examined. The findings indicated that successful problem solvers tend to develop a model for the problem which is considered as the problem model strategy while unsuccessful problem solvers attribute their solution strategy on numbers and keywords chosen from the problem.

Additionally, Lee and Nelson (2005) investigated the effects of generative and completed concept maps on the prior knowledge while solving well and ill structured problems. The higher prior knowledge groups' performances, which use generative concept maps, are superior to the lesser prior knowledge groups. Eseryel (2006) investigated whether there are distinguishable patterns among the instructional design experts in ill-structured problem solving processes. She used expert thinking in problem solving process as a base for the evaluation. The results showed that there are apparent patterns between expert designers in their problem solving process.

The Routine of Becoming an Expert

Aforementioned studies attempting to compare experts to novices were highly common in the expertise literature. Many authors explored the nature of expertise to understand the possible methods to support the novices move one step further in their education. Observing the experts and exploring their behavior patterns would help to develop successful systems to support the novices. Ericsson, Charness, Feltovich, Hoffman (2006) accepts that novices could accomplish experts' abilities. Since the perception of the definition of the terms would change with this assumption, they consider novice term in a general logic and accept that there could be a group range between people non-experts, from naives to journeyman. Hoffman (1998) developed a proficiency scale which shows the range of expertise given in Table 2.1 (cited in Ericsson, Charness, Feltovich & Hoffman, 2006).

Table 2.1. *A Proficiency Scale* (adapted from Hoffmann, 1998 cited in Ericsson, Charness, Feltovich & Hoffman, 2006, p.22)

Naive	One who is totally ignorant of a domain
Novice	Literally, someone who is new- a probationary member. There has been some minimal exposure to the domain.
Initiate	Literally, a novice who has been through and initiation ceremony and has begun introductory instruction.
Apprentice	Literally, one who is learning – a student undergoing a program of instruction beyond the introductory level. Traditionally, the apprentice is immersed in the domain by living with and assisting someone at a higher level. The length of an apprenticeship depends on the domain, ranging from about one to 12 years in Craft Guilds.
Journeyman	Literally, a person who can perform a day's labor unsupervised, although working under orders. An experienced and reliable worker or one who has achieved a level of competence. Despite high levels of motivation, it is possible to remain at this proficiency level for life.
Expert	The distinguished or brilliant journeyman, highly regarded by peers, whose judgments are uncommonly accurate and reliable, whose performance shows consummate skill and economy of effort, and who can deal effectively with certain types of rare and rare or "tough" cases. Also, an expert is one who has special skills or knowledge derived from extensive experience with sub domains.
Master	Traditionally, a master is any journeyman or expert who is qualified to teach those at lower level. Traditionally, a master is one of an elite group of experts whose judgments set the regulations, standards, or ideals. Also, a master can be that expert who is regarded by the other experts as being "the" expert, or the "real" expert, especially with regard to sub-domain knowledge.

Comparison studies were examined in terms of the level of proficiency that the novice could accomplish (Chi, 2006). He also added academic qualifications, the prior experience in terms of time period on performing the tasks could be considered as measurements like graduate students, undergraduate students. They also added in some cases, tests could be used for assessing the individuals with "domain-specific knowledge or performance tests" (Chi, 2006, p.23).

Moreover, improving novices to expert level is still being explored by many researchers. The effect of prompting feedback mechanism is another issue introduced. As Ifenthaler (2009; 2010) expressed the importance of feedback to aid and administrate the learning process. He also clarified the importance of feedback since it assist the mental models and enhance expertise and expert performance. In order to examine different forms of model-based feedback for improving expertise Ifenthaler (2009) presented new frameworks of model-based feedback. In another study, effect of different kinds of automatically produced feedback was explored. The participants were asked to write texts and develop CMs considering their comprehension on climate change and three different types of model-based feedback were given. Although there is no apparent effect of automatically created feedback system on the demonstration of the participants, it was found that CMs were close to expert resolutions in terms of their structure and visually than the text (Ifenthaler, 2010).

2.3 Exploring Eye Movements

Recording eye movement has been popular among researchers for over a century (Wade & Tatler, 2005). In early periods, eye tracking research studies usually depend on the bench-mounted devices. Then head-mounted devices followed bench-mounted ones for the tasks requiring active movement which last over 50 years have been used. After 1980s, mobile eye tracking devices emerged as a result of the impact of the changes in technology in eye tracking studies (Land, 2007). Through the changes in technology, research studies on eye movements have also become more popular and started to be used among various fields.

Particularly, the popularity of eye tracking was raised in the 1970s. The main reason lying beneath was related with both the developments in eye tracking technology and several attempts on the field of psychology, like "psychological theory to link eye tracking data to cognitive processes" (Jacob & Karn, 2003). Most of the research studies at that period focused on the eye movement and the relation between the cognitive processes (Rayner, 1998; Jacob & Karn, 2003). The potential of eye movements in terms of disclosing the fundamentals cognitive process (Just & Carpenter, 1984; Rayner, 1995, 1998) and the connection between the eye behavior and reasoning (Just & Carpenter, 1984) were revealed in the literature. Since most of the research studies' concern was to link the eye movements and cognitive processes, the popularity of the eye tracking studies might be considered a result of the passion of human being opening a window to mind and comprehend the cognitive process in depth.

Interestingly, at the same period in 1970s eye tracking studies interfered for a while. Especially, the main reason was related with the data analysis process, the huge data coming from eye tracking device was a critical problem (Jacob & Karn, 2003). However, in mid 1970s, the advances in eye tracking technology made it easier to analyze the data with more accurate results (Rayner, 1998) and eye tracking technology again gained the earlier popularity among researchers. Various studies have been conducted on eye movement data analysis (Kliegl, 1981; Kliegl & Olson, 1981; Pillalamarri, Barnette, Birkmire & Karsh, 1993 cited in Rayner, 1998) and eye tracking systems and their features were explored by researchers (Deubel, 1995). Thereafter, the developments in eye tracking technology enabled researchers to find pioneering strategies that allowing them to detect the changes in eye movements occurred in visual display contingently (Rayner, 1998). In this respect, researchers advanced new theories related with language processing and attempted to apply eye movements to determine the underlying cognitive process during reading process (Rayner, 1998).

In eye tracking studies there are different metrics like fixations and saccades to measure the eye movements. *Fixation* is defined in the literature as "pauses over informative regions of interest" (Salvucci & Goldberg, 2000, p.71). Additionally, saccades are defined as small movements which are assumed less importance among researchers. According to Poole & Ball (2006), during saccades encoding process is not happening. Researchers described the speed of saccades variously. Rayner (1998) indicated saccades as “rapid movements of the eyes with velocities as high as 500º per second” (p.373), while Crowder and Wagner (1992) stated the saccades as 100 to 200 per second. For different activities approximate mean FD and saccade length were given in Table 2.2.

Table 2.2 *Approximate Mean Fixation Duration and Saccade Length in Different Activities* (Adapted from Rayner, 1998, p.373)

Task	Mean Fixation duration (ms)	Mean saccade size (degrees)
Silent reading	275	2 (about 8 letters)
Oral reading	275	1.5 (about 6
Visual search	275	letters)
Scene	330	3
perception	375	4
Music reading	400	1
Typing		1

In order to clarify the potential of eye movement research studies and the terms, some of the metrics and their interpretation practically were given in Table 2.3.

Table 2.3 *Fixation-derived Metrics and How They Can Be Interpreted in the Context of Interface Design and Usability Evaluation* (references are given to examples of studies that have used each metrics) (Adapted from Poole & Ball, 2005, p.213)

Eye movement metric	What it measures	Reference
Number of fixations overall	More overall fixations indicate less efficient search (perhaps due to sub-optional layout of the interface).	Goldberg and Kotval (1999)
Fixations per area of interest	More fixations on a particular area indicate that it is more noticeable, or more important, to the viewer than the other areas.	Poole & Philips (2004)
Fixations per area of interest and adjusted for text length	If areas of interest are comprised of text only, then the mean number of fixations per area of interest can be divided by the mean number of words in the text. This is useful way to separate out a higher fixation count, simply because there are more words to read, from a higher fixation count because an item is actually more difficult to recognize.	Poole & Philips (2004)
Fixation duration	A longer fixation duration indicates difficulty in extracting information, or it means that the object is more engaging in some way.	Just and Carpenter (1976)
Gaze (also referred to as dwell, fixation cluster and fixation cycyle)	Gaze is usually sum of all fixation durations within a prescribed area. It is best used to compare attention distributed between targets. It also can be used as a measure of anticipation in situation awareness. If longer gazes fall on an area of interest before a possible event occurring.	Mello-Thoms, Nodine, & Kundel (2004); Hauland (2003)

Table 2.3 (continued)

Eye movement metric	What it measures	Reference
Fixation spatial density	Fixations concentrated in a small area indicate focused and efficient searching. Evenly spread fixations reflect widespread and inefficient search.	Cowen, Ball & Delin (2002)
Repeat fixations (also called post-target fixations)	Higher numbers of fixations off target after the target has been fixated indicate that it lacks meaningfulness or visibility.	Goldberg and Kotval (1999)
Time to first fixation on target	Faster times to first fixations on an object or area mean that it has better attention-getting properties.	Byrne, Anderson, Douglas & Matessa (1999)
Percentage of participants fixating on an area of interest	If a low proportion of participants is fixating on an area that is important to the task, it may need to be highlighted or moved.	Albert (2002)
On target (all target fixations)	Fixations on target divided by total number of fixations. A lower ratio indicates lower search efficiency.	Goldberg and Kotval (1999)

Limitations of Eye Tracking

Although eye tracking studies became flourished and the potential benefits were discovered at that period, it has also shortcomings; technical issues (Collewijn, 1999; Goldberg & Wichansky, 2003) and problems relevant to handle the huge data analysis process (Jacob & Karn, 2003). Another limitation of eye movement is being dependent to individuals and the huge data sets produced. Dealing with this huge and complex data requires considerably much time to be examined manually or by immature techniques (Salvucci, 1999). Sensitivity of the eye tracking system is another constraint during monitoring the participants ‘who have eyewear that interrupts the normal path of a reflection, such as hard contact lenses, bifocal and trifocal glasses, and glasses with super-condensed lenses’ (Poole & Ball, 2005, p. 216). In addition, eye movement could provide only traces on the consideration of a person and need making inferences from the observed data. Being open to interpretations can be considered as another constrain of the eye movement data since some of the interpretations might be inaccurate (Salvucci, 1999). Moreover, Rayner (1998) denoted the deficiency of eye tracking data in terms of the limitations of making generalizations especially on cognitive tasks and difficulty of generalizing results to different tasks. Another constrain is related with the ‘imperfect oculomotor control’ of individuals. Feng (2011) underlines that the saccadic movement of the eye which can create a varying delay of approximately 150 msec (Carpenter, 1999 cited in Feng, 2011) between the overshooting or undershooting the target and focusing on the target renders difficult the conclusion about the exact time when the cognitive decision was made (Feng, 2009 cited in Feng 2011).

Existing Research Studies on Eye Behavior

Especially in the field of psychology, before 1970s the general tendency between researchers who were interested in eye tracking was to elude the high-level cognitive process “cognitive factors such as learning, memory, workload, and deployment of attention”. Their prior concern was exploring the link between the “eye movements and simple visual stimulus such as target movement, contrast, and location” (Jacob & Karn, 2003, p.2). The research studies in the literature on eye tracking have a wide range from daily activities to very complex tasks. Land, Mennie and Rusted (1999) explored everyday activities like how participants make tea and which acts they performed during this activity while Hayhoe (2000) focused on peanut butter and jelly sandwiches preparation process. Reading and information processing are other well researched issues between researchers (Clifton, Staub & Rayner, 2007; Rayner, 1998; Just & Carpenter, 1980). Some theories and hypotheses related with this view are developed as theory of reading to establish a perspective by using the fixation to comprehension (Just & Carpenter, 1980) and "eye-mind hypothesis" which deal with the positive relation between the eye behavior and thinking (Just & Carpenter, 1984). Witzel, Witzel and Foster (2012) compared different methodologies in reading process. They pointed out the importance of eye tracking in terms of providing explicit signs to uncovering the characteristic differences in the online learning process. This process can enable to understand the sentence comprehension system.

Psychologists also paid attention to eye movement studies that it gives information on the process of cognition and perception of the individuals. There are many studies explored in the literature focusing on the cognitive process (Just & Carpenter, 1984; Rayner, 1995, 1998). Exploring eye-movements during the information processing tasks offers a wide range of eye movement applications from different disciplines (Rayner, 1998).

Althoff and Neal (1999) explained that memory might be influenced by the eye movement characteristics and it has a vital function for cognitive information processing (cited in Murata & Nobuyasu, 2005). Mental workloads of the participants by using eye movements were another issue explored (May, Kennedy, Williams, Dunlop & Brannan, 1990). In addition, working memory capacity between individuals by using eye fixations (Calvo, 2001), and concurrent memory load (Roberts, Hager, & Heron, 1994) were investigated. Attention and the connection between eye movements have been another widely explored issue (Velichkovsky, Dornhoefer, Pannasch & Unema, 2001, Remington, 1980; Reuter-Lorenz & Fendrich, 1992; Shepherd, Findlay, & Hockey, 1986 cited in Rayner, 1998). Exploring search behavior of the participants (Granka & Joachims & Gay, 2004; Zelinsky & Steinberg, 1995) and reaction time in visual search (e.g. Murata & Nobuyasu, 2005) were other popular issues for eye tracking studies. As Albert et al. (2005) remarked "numerous research studies in reading have stressed eye movement measurements as potential behavioral indices expressing ongoing visual and cognitive processing" (p. 593).

Educational Value of Eye Behavior

The educational value of the eye behavior was also attracted the attention of the researchers (Lowe & Boucheix, 2011; Hyöna, 2010; Jarodzka, Scheiter, Gerjets & Van Gog, 2010; Ozcelik , Karakus, Kursun & Cagiltay, 2009; She & Chen, 2009; Patrick, Carter & Wiebe, 2005; Grant & Spivey, 2003). Mayer (2010) summarized six eye tracking studies in terms of practical, theoretical, methodological involvements to improve multimedia learning. Eye tracking research provides a remarkable way for examining the multimedia learning theories. These studies increased the awareness on the understanding of learning and thinking process with graphics. Total FD on related areas of graphic is an intentional action to examine the perceptual processing, and produce better learning as a result of cognitive processing. Land (2007) indicated learning process and potential of eye movements as a future direction for eye tracking research. Hyöna (2010) investigated the cognitive process of human during multimedia learning and how eye tracking could be used in this process.

In recent years eye tracking studies started being popular among science education researchers (Wiebe, Slykhuis & Annetta, 2007; Ariasi & Mason, 2011). Ariasi and Mason (2011) investigated the influence of text structure on both cognitive processes during the reading of a science text and also on conceptual learning from the text. They explored whether different forms of cognitive processes would occur while reading a refutational and non-refutational text. Additionally, with the aid of eye movement analysis they studied whether a close relation exists between the off-line learning outcomes and on-line cognitive processing. The findings confirmed that refutational text readers learned better than the non-refutational text readers. Eye tracking data also revealed that scientific concepts fixated longer period of time by the refutational text reader than the non-refutational text readers. They concluded that the clues on visual attention only predictable for refutational text readers and reading much refutational text result with better learning.

Patrick, Carter and Wiebe (2005) explored the students' understandings of DNA replication which is represented visually. The results of eye movement measures showed 2D and 3D graphics had distinct features. Differentiating the relevancy of the information is a common problem among students; better designed instructional representations might help them to find the relevant information more easily. They concluded that this study has an implication for providing better designed instructional representations.

Amedieu, Gog, Paas, Tricot and Marine (2009) investigated "the effect of prior knowledge and concept-map structure on disorientation, cognitive load, and learning from hypertext" (p.378). They used eye movement and navigation data to support and gain detailed understanding on their view. The results showed that hierarchically structured CMs produced less mental effort for both higher prior knowledge and lower prior knowledge participants. On the other hand, lower prior knowledge participants achieved more conceptual knowledge while higher prior knowledge participants gained more factual knowledge in hierarchical CMs than network structured CMs. In addition higher disorientation was found in lower prior knowledge participants through the learning process.

Van Gog, Kester, Nievelstein, Giesbers and Paas (2009) investigated different ways for revealing the cognitive process by combining verbal protocol, eye tracking and concept mapping. They were interested in cognitive load theory and how the acquired knowledge could be used for refining or validating the theory and informing instructional design.

2.4 Exploring Cognitive Process with an Educational Perspective

Understanding the human learning is an old issue which psychologists are still trying to enlighten. In the literature, there are several attempts for clarifying the cognitive process with the aid of human beings' thinking ability. Abstraction is one of the most powerful thinking ability of human which is not a passive process indeed. For comprehending the abstraction process, it is essential to understand the human thinking mechanism. According to Hunt (1962), this may contribute the understanding of the structure of human action and also improving the knowledge organization. Weinstein and Mayer (1986) also explained "cognitive approach to learning seeks to understand how incoming information is processed and structured into memory" (p. 316).

For determining information on learning and the cognitive processes of individuals, it is essential to harness information on human memory and its complex systems. According to Novak and Canas (2008), human memory consists of independently structured systems like long term, short term and working memory. The information is processed and organized in the working memory by establishing relations with knowledge in the long term memory. For this reason, working memory capacity is very limited and people capable to process little psychological units at one moment. This capacity is also related with the retention of information. Anderson (1992) stated that "for structuring large bodies of knowledge requires an orderly sequence of iterations between working memory and long-term memory as new knowledge is being received" (cited in Novak & Canas, 2008).

Structuring information is crucial for giving meaning for the process of brain that encoding and decoding is attempting to verbalize the process. Encoding is defined by Goldstein (2005) as a "process of acquiring information and transforming it into memory". (p.193). Encoding refers obtaining information into Long Term Memory and this process. While decoding is described as "the process of restoring original messages from the forms in which they were transmitted, stored or enciphered by applying a suitable code" (Krippendorff's Dictionary, 1986). Decoding is also known as a reverse of encoding. Since human beings always organize the materials, stuff and tasks in an order, memory system also use the system of organization for acquiring information (Goldstein, 2005). Especially Bransford and Johnson (1972) emphasized the importance of the relation between the organization of information and ability to remember. They stressed the organization of information with using pictures enables to remember more easily (cited in Goldstein, 2005). The organization of the memory is related with the representation of knowledge. In terms of long-term memory, one of the most well-known view is that individual is organizing the meaning of words in a hierarchical network (Collins & Quillian, 1969, 1972 cited in Goldstein, 2005). In the literature the main assumption on the hierarchical structure is that the reaction time on a specific question or statement that it requires verification (Medin, Ross & Markman, 2005). This idea is verified by the experiments (Collins & Quillian, 1969; Landauer & Freedman, 1968) on the hierarchical effect prediction and it constitutes the hierarchical network model (cited in Medin, Ross & Markman, 2005). The hierarchical memory structures the words within familiar categories and this cause activation in the memory. According to Quillian (1968), this hierarchical structure is also identical with the CM structure that it consists of nodes and links much like CMs and the relationships among concepts can specify the meaning of the concept.

Accordingly, Novak and Canas (2008) expressed the importance of concept mapping since CMs are beneficial for organizing and structuring the knowledge in a well-structured manner while establishing relationships between units and their interactions. Concept maps' functional role is explained by many authors in the literature (Novak, 2010; Ellen, 2000; Yin et all, 2004; Zele, Lenaerts & Wieme, 2004; Novak & Gowin, 1984). CM is a tool which enables individuals to construct frameworks while allowing the retention of the new knowledge for a long period of time (Novak, 1990; Novak & Wandersee, 1991). These studies supported the view of CMs are the representation of the knowledge in a visual way. Novak and Gowin (1984) declared the potential of CMs to reveal the cognitive organization of students.

The importance of cognitive structure for meaningful learning which is related with the organization of concepts in mind was explicited by Ifenthale, Masduki and Seel (2011). Parallel to this view, Ausubel (1963) indicated that "If existing cognitive structure is clear, stable, and suitably organized, it facilitates the learning and retention of new subject matter. If it is unstable, ambiguous, disorganized, or chaotically organized; it inhibits learning and retention" (p.217). Jonassen (1987) also mentioned the promise of identifying the cognitive structure of pupils for aiding the instructors during the organization of materials (cited in Jonassen, Beissner & Yacci, 1993). Additionally, this process may help instructors to determine the knowledge gaps and linking the new information with the prior knowledge. The nature of a domain expert's cognitive structure is regarded as possessing a huge number of links which is interrelated to concepts comparing to novices. This difference fascinated the researchers to assess and compare novice knowledge with experts to establish strategies for filling this gap (Ifenthale, Masduki & Seel, 2011).
The potential of recording eye movement to uncover the cognitive process is another issue for researchers. According to Van Gog, Kester, Nievelstein, Giesbers and Paas (2009), eye movements is suited to explore the cognitive process and eye fixations present a suitable measure in cognitive tasks (Just & Carpenter, 1976). Different combinations of techniques like verbal protocol, eye tracking and concept mapping used to reveal the cognitive process for instructional and research purposes (Van Gog et al., 2009).

Summary of the section

In this section, the roots of concept mapping and related studies were summarized while acknowledging the shift from rote learning to meaningful learning. The potential of CMs in terms of visualizing knowledge and linking between prior knowledge was a well researched issue among researchers. Using CMs as a metacognitive tool was another aspect mentioned by the researchers. Concept maps' promising role in the assessment process is also discussed issue in the literature. It is acknowledged that there are several studies examined CMs for different purposes which could not be covered only in this section.

Exploring the visual representations and conceptual understanding of the participants in science education has been studied by the researchers frequently. In recent years, exploring the CM development process drew attention of the researchers. Additionally, the cognitive dimension was discussed while emphasizing the hierarchical structure of the brain and the similarities of concept mapping with the knowledge structure in mind were explained. Although the literature on CM is a vast area and many focuses on the usage of CM's for effective instruction and assessment purposes, there is an agreement among researchers about the potential of CMs but the cognitive process and underlying theme is not well explained.

The relation between cognitive process and eye tracking is appreciated among researchers and the potential of eye behavior is started to be realized by also many educators. Eye-tracking method allows the researchers to explore the process in depth and facilitate researchers to focus on specific themes. Moreover, the eye tracking devices enables the researchers to observe the behavior of the participants by analyzing frame by frame which prevents missing points. Although in the literature there are many studies using paper and pencil during concept mapping process, in the paper-pencil concept mapping process the valuable information regarding the construction process could not be gathered because of the deficiencies of the method. Because of the usable nature and cost effectiveness, computer based tools started to be preferred in recent years. Eye tracking also supports this process and may provice valuable data source and may give chance to observe clues on the process. Observing the process with the aid of eye tracking device allow researcher to define the behavior patterns among participants without missing any points.

This study aims to seek for answers on the CM development process while considering not only the visual representation aspect but also the cognitive processes of its development. Exploring the process while focusing on the cognitive processes is not a well examined issue, the behaviors and individual strategies may be a valuable source of information for both educators and researchers as means to comprehend the process more accurately. Also, assisting the students in the learning process requires a cognitive analysis of the behavior that visualizes the knowledge structure which is important for understanding the process and supporting it more precisely. Since, in terms of representing the existent knowledge by using visual strategies is effective, CMs may influence the process directly and it is essential to understanding the process. Consequently, more effective strategies and enriched concept mapping usages might be provided.

This study is crucial in terms of assisting teachers and students by gathering information on the process of CM construction and displaying general patterns of the students. Analyzing the cognitive processes of the students may help not only researchers but also instructors to introduce the points that the students are poor or deficient, and teachers may help the students more effectively and adequately with the aid of this information. In addition to this, exploring the process may give potential clues to increase not only map quality but also the understandings of the learners while considering their perspectives more detailed. Guiding the learners at the right time and with an appropriate way could help them to construct their understandings on a subject more effectively. For that reason, exploring the process could enlight both the instructors about how they could guide the learners effectively and also could give suggestions to learners to improve their performances with the aid of the gathered clues from experts. Moreover, as CMs are beneficial tools for representing existing knowledge visually and meaningfully rather than memorizing the facts and write down them, this kind of strategies enable students to analyze and putting through their exist knowledge with new ones while considering their relations.

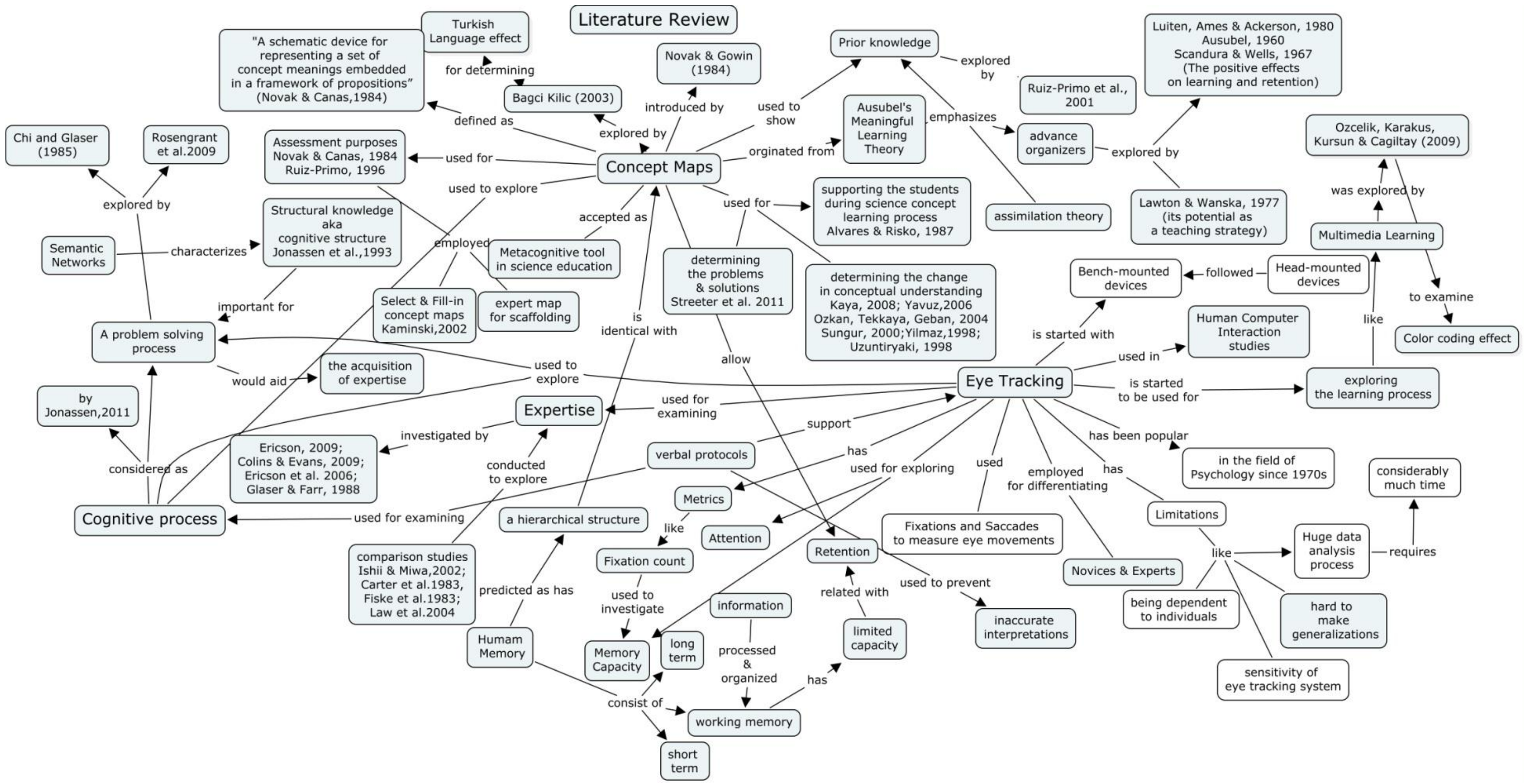


Figure 2.3 Summary of the Review of Literature

CHAPTER 3

RESEARCH DESIGN AND METHODOLOGY

This chapter provided a detailed picture of the research methodology while presenting research questions, overall research design (pilot and main study including two phases), participants, data collection methods, instruments, data analysis process, researcher's role, validity and reliability issues, limitations. Since overall research design included three different stages, it can be seen as a prototyping cycle process and all these sections were presented through this context. It was aimed to provide information about the design procedures and data collection including the knots and how researcher overcomed the problems occurred.

3.1 Research Questions

The main purpose of this study was to explore participants' cognitive processes during CM development processes. This study attempted to provide answers on comprehending the cognitive process of participants during CM development by taking both experts' (subject matter experts) and novices' (pre-service teachers) points of views into account. Throughout this study, the following questions were explored. Sub questions have also been proposed to help while answering the main research question.

The Main Research Question

- How do novices and experts establish their concept mapping processes?

<u>*Sub questions:*</u>

1. Do novices and experts use specific strategies during the concept map development process?
2. How does the concept map development processes differ within novices and experts?
   2.1 Are there differences between novice and expert participants in terms of their eye behavior (e.g. fixation count, visit duration and fixation duration)?
   2.2 Are there any differences among experts' and novices' concept maps in terms of content richness?
3. What are the factors that affect concept map development process?

3.2 Research Design

In this study, research design included researcher's plan of work, the selected methodology for this study and the procedures. As a research design, case study selected which is a qualitative research method. In this context, the main purpose of this study was to have an understanding about the participants' cognitive processes throughout the CM development process while bearing in mind both experts' and novices' viewpoints. This study also tried to find the routes for supporting and improving the CM development process and find specific solutions for the existing obstacles.

3.2.1 Selected Research Methodology

In this study, the purpose was to have in-depth information about the CM development process and the views of novices (pre-service teachers) and experts (subject matter experts) during the process. Thus, the researcher focused on presenting a detailed picture of the phenomenon and chose qualitative research method as a selected research methodology.

Bogdan and Biklen (2003) explained the characteristics of qualitative research as;

1) Data are collected in natural settings and in this natural setting researcher have a significant role
2) Data in qualitative studies are usually explanatory and consist of expressions than numbers
3) The attention is on the process rather than the products or results.
4) The qualitative researchers use inductive approaches for analyzing data
5) The researchers concentrate on the meaning of the experiences of their participants. An interaction between the researcher and participant can be a better explanation for the procedure of qualitative research study.

Case Study

In this study, case study method has been used as a qualitative research method. Case is defined by Merriam (1998) as 'people such as a student, a teacher, a principle or groups such as a school, a community" (p.27). Yin (2009) defines a case study as;

> "an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident" (p.18)

This study consists of a pilot study and main study including two phases. They were analyzed to explore the novices' and experts' cognitive processes by examining their CM development process. In the pilot study, the participants were asked to develop a CM and their eye movements and video recordings were examined. The qualitative findings guided the researcher to carry this study one step further, another qualitative instrument 'interpretative essay', which includes questions regarding the CM development process of the participants, was employed to have a better understanding regarding the cognitive process. While starting the study, the researcher decided to use a single case for exploring the cognitive process of the participants. However, after the first data collection she realized that another data collection is necessary by using a narrative way of explaining the cognitive process. Although the researcher collected data by using different instruments than the first phase, the participants did not want to write more about the process because of the data collection process is intense for many of them and they also explained that they were tired about the CM development and they were not willing to write their feelings in detail.

Hence, the researcher changed the strategy where instead of asking participants to report their steps in a written form, they were requested to talk about their behaviors. Participants were asked to develop another CM in the last phase which is a combination of the previous phase while adding another dimension to the study as expertise. This process which is called debriefing session or retrospective review, the participants watched their own CM development recorded by eye tracking device and responded to the questions related with their acts and steps in this video. This process was recorded by the researcher to have a better understanding about participants' comments and explanations. The observations were recorded by the video recorder in the laboratory environment and analyzed after the sessions. These two phases can be seen as extensions of each other, in other words these two studies and pilot study were independent but associated cases. Each phase examined independently and each phase contributed to the other phase.

3.3 Participants

In this study, the researcher concentrated on different sampling techniques while determining the groups of participants. The researcher chose purposeful sampling and under this convenience and criterion sampling techniques were used for this study.

In the literature, there are two types of sampling used by researchers' random and purposive sampling (Yildirim & Simsek, 2008). Creswell (2003) identified purposeful sampling as a procedure which aims to select the individuals or settings purposefully that have the potential to help the researcher in terms of finding necessary information to solve the problem. Frankel and Wallen (2011) also emphasized that “purposive sampling increases the likelihood that the variability so common in social phenomena will thereby be represented in the sample” (p.433). According to them many researchers tend to use purposive sampling instead of random sampling in qualitative research studies (Frankel & Wallen, 2011). Patton (2002) explained that the underlying reason for choosing purposive sampling is related with selecting “information-rich cases for study in-depth” (p.46). Purposeful sampling type includes nine other groups as; extreme case sampling, intensity sampling, maximum variation, homogenous samples, typical case sampling, critical sampling, snowball or chain sampling, criterion sampling and convenient sampling (Frankel & Wallen, 2011; Patton, 2002).

Frankel & Wallen (2005) expressed the difference between purposive sampling and convenience sampling, as purposive sampling is more than using a sample who is just available; instead it is using inferences while selecting sample based on the prior knowledge of the researcher. Being dependent to the researcher’s inferences is a major disadvantage for the purposive sampling. According to Johnson and Christensen (2004), convenience sampling consisting of people who are available or easily attained and ready to be participating to the research study. Also Frankel and Wallen (2000) stated that convenience sampling is appropriate and essential studies that when the researcher explained the characteristics of the participants adequately. Frankel and Wallen (2005) agree with the statements of Johnson and Christensen (2004) in terms of the statements on the giving necessary information on the participants’ characteristics and demographics. The reason for choosing the convenience sampling technique for this study is related with the sampling limitation and the requirements of using eye-tracking device. In this study, a specific group has chosen for collecting data. Even the pre-service teachers who studied in other universities, could meet the criteria of being participants, it is not applicable to bring them to HCI Research and Application Laboratory which is situated in Middle East Technical University (METU) campus for several times. For this reason participants who study in the same campus participated to the study.

In this study, while determining the groups some criteria defined for each group. Two types of criteria were determined by the researcher for this study.
The first criteria were established for novice participants, as;

1. Being an undergraduate student in the Elementary Science Education program
2. Having prior experiences on science related subjects (Biology and Chemistry)
3. Being fluent in English
4. Having basic computer skills
5. Having knowledge and experience on concept mapping
6. Being convenient to the METU's HCI Laboratory environment

Second criteria were established for expert participants, as;

1. Having at least five year experience in the field of Science Education
2. Being fluent in English
3. Having experience on concept mapping
4. Having basic computer skills
5. Being convenient to the METU's HCI laboratory environment

The sampling selection process was explained in detail under three subheadings as Pilot study, Phase 1 and Phase 2. In addition to this, two types of participant groups as novices and experts, and two different groups of participants participated to the study. The pilot phase included information about novice participants who are pre-service teachers, while Phase 1 was including information a new novice group who were pre-service teachers, too. In Phase 2 information about both novice and expert participants were explained. These groups were explained not only giving emphasis to their characteristics in general but also their expertise.

Pilot Study Participants

Before the real study, for each group of the participants (experts and novices) two pilot studies were conducted to check the accuracy and applicability of the methods, instruments and procedures. As novices 16 pre-service teacher who were 4th year students in the Elementary Science Education department of METU, Turkey in 2007, spring term participated to the study. 12 out of 16 participants were female, whereas 4 male participants participated to the pilot study. Age of the participants was ranging between 20 to 25 years of age. As experts, 1 female and 2 male participant participated to the study. Their ages were ranging between 28-45 years.

Main Study

Phase 1-Participants

In the main study Phase 1, a new novice group participated to the study that was different than the pilot study. This group of participants who are accepted as novices included 12 participants who are 3rd year pre-service teachers from the Elementary Science Education department of METU, in Turkey in 2008, Fall Term. The gender distribution was 9 female and 3 male participants, whose age range between 21 to 23 years. The researcher collected data twice from this group.

Phase 2-Participants

This phase consisted of two different groups of participants; novices and experts. As novice group, 17 participants participated, 16 female and 1 male. In addition to the same group as in Phase 1, some new novice participants participated to this study but they became 4th year pre-service teachers and data were collected in 2009, fall term. The last group for this study included a group of subject matter experts who had at least 5 years expertise in the science education field. This group consisted of 6 participants who are 5 female and 1 male participants. 1 participant excluded due to the eye movement quality requirement. The first group's ages were in a range of 21 to 25 years while the second group's ages were in a range of 30 to 45 years of age.

Novice Group

The group of participants who accepted as novice group contributed to this study was; 4th year pre-service Elementary Science Education teachers of METU, in Turkey. The group was chosen associated with science since CM development is much more suitable to science education due to its compatibility with the content. All participants enrolled in the required Chemistry, Biology and the method course which was related with instructional methods and techniques in advance level. The participants were fluent in English. As a university requirement all 1st year students need to take a course which is related with the basic technical knowledge on computers and the Internet, hence they had the basic computer skills. They were competent enough to use computers and software of the CMs without having any problem. Although they had no problems on using computer, they required to have some basic knowledge on concept mapping software (Cmap Tool). For this reason, the researcher gave a training session which took one course hour to make them familiar with using Cmap Tool environment.

Expert Group

The group of participants was in expert position selected due to their skills and backgrounds. Experience and expertise need to be well defined why researcher chose this group what are their specialties' how they can help researcher to understand the expert group behavior. This group of participants was chosen from universities' science education related departments who have at least 5 years expertise in science education field, had Master and PhD degree. The convenience and suitable group selected and asked them to participate to the study voluntarily. While determining this group, their knowledge on subject matter, English proficiency, the experience in the field and their knowledge on concept mapping were used as criterion. In addition to this, it was required them to know concept mapping and experienced Cmap Tool software beforehand. In order to elicit the experts, who have used other Cmap tools or did not have any experience with a computer based Cmap Tool, to be accustomed to Cmap Tool software training was given to them. See Figure 3.1 for the visual representation of the groups.

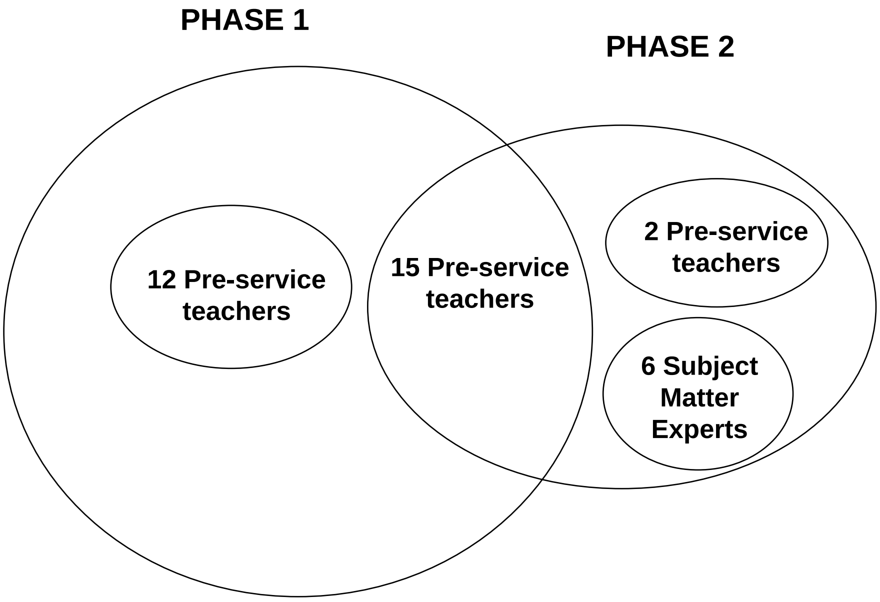


Figure 3.1 Visual Representation of the Participants

For each study, respectively 12 pre-service teachers, 17 pre-service teachers and 6 subject matter experts participated to the study. The details of the participants are given in Table 3.1.

Table 3.1. *Descriptive Information of Participants*

	Phases	Gender	
		Female	Male
Novices	Pilot	12	4
	1	9	3
	2	16	1
	Total	25	4
Experts	Pilot	1	1
	1	5	1
	Total	6	2

3.4. Data Collection and Instruments

There are four methods which are common by qualitative researchers for gathering information in qualitative research studies; participation in the setting, direct observation, in-depth interviews and analysis of the related materials and documents (Marshall & Rosmann, 2006). In this study, following multiple information sources were used by the researcher;

1. Face-to-face interviews with all participants after the CM development process (Retrospective review and questioning about the process)
2. Observation: The subjects were observed in the HCI laboratory environment; both the gestures and mouse-keyboard movements were recorded by video recorder.
3. Document analysis:
   a. Analyzing the developed CMs
   b. Open-ended inventory question responses about the CM development and interpretative essay responses
   c. Prior knowledge test administered immediately before the CM experiment
4. Comments made by the novices and experts

In qualitative studies, validity and reliability issues requiring being more perceptive various data collection methods were used while collecting data. Parallel to this view, Yin (2010) suggested to use different data collection methods; interviewing, making observations, gathering personal documents and other written materials and collecting information researcher's feelings.

3.4.1 Instruments

In this study, different instruments were used by the researcher; some of the instruments were developed by the researcher and some of them taken from other studies.

1. Prior Knowledge Test

a. Cell Concept Test: The test was prepared for assessing the prior knowledge of the individuals on "Cell" concept. The test consisted of 14 multiple choice questions on 'Cell' subject. The questions selected from a general exam which administered across the country by a government institute. The reliability and validity issues were checked with the help of subject matter experts by this institute. For content validity, an expert examined the questions regarding the appropriateness of the questions. For this reason validity and reliability issues were ensured before this study.

b. Matter Concept Test: The test was prepared for assessing the prior knowledge of the individuals on 'Matter' concept. It consisted of 25 multiple choice questions on Matter subject. The test was taken from a doctoral dissertation (Yavuz, 2005), reliability and validity was ensured beforehand. The reliabiliry of the test was .79. Content validity of the test was ensured by a group of expert teachers for the appropriateness of the items.

Frankel and Wallen (2005) explained content-related evidence of validity as the appropriateness of the instrument in terms of the content and the format which should be consistent with the variable defined and sample. For providing the content-related validity the content and the format of the test were checked by a subject matter expert. The tests were prepared in the native language of the participants to prevent the misconceptions on the concept.

2. Prior Experience on Concept Mapping Inventory

An inventory consisted of 9 open-ended questions to explore the background of the participants was administered. In the pilot study, questions were asked to explore the prior experiences of the participants and then they were revised with respect to the pilot study results into newer version. The inventory was first checked by a subject matter expert for ensuring the content validity and then in the pilot study the questions were tested whether they were working or not. The questions were asked in participants' native language to prevent confusion (See Appendix C). The English translation of the inventory questions are given below.

Inventory Questions

a. Have you ever developed a concept map? If you have developed, how many?
b. What kind of concept maps did you develop?
c. In general, regarding which subjects or contents did you develop concept maps?
d. Do you think are there any suitable subject areas for concept maps? Why these subjects are suitable for concept map development? Could you please explain?
e. Do you think concept maps are beneficial for you? Why?
f. While you are developing a concept maps, what are you paying attention?-
g. Do you have a specific strategy while developing a concept map? If you have, in general what kind of strategy are you using?
h. In your future teaching life, are you planning to use concept maps? Why?
i. If you are planning to use concept maps, what kind of maps do you prefer to use? Why?

3. Interpretative Essay:

Although eye behavior is considered as a good indicator for investigating cognitive process, it requires other types of data for supporting it while explaining the process in depth. Therefore, the researcher developed some open-ended questions for examining the process while gathering data from participants in a narrative way. The main purpose for developing this kind of instrument was to enable participants to express themselves more systematically and give some reminders about the process (See Appendix D).

Interpretative Essay Questions

1. How did you start structuring your concept map?

2. What did you think before you placing the concepts and links?
3. What did you do during the labeling process? Did you delete and re-write some concepts or links? Why?
4. Did you follow a strategy during concept map development process? What kind of strategy did you follow, from top to bottom or bottom to top, etc.? Why did you choose this strategy?
5. In which parts did you develop map easily than the other parts? (Labeling, branching, structuring the relationships)
6. What difficulties have you experienced and what did you do for resolving them?
7. Did the predetermined subject affect your concept map development process? How?
8. During the concept map development, was handout helpful? In which aspects?

3.4.2 Materials and Equipments

The study was actualized at the HCI Laboratory at METU. The laboratory has an experimentation room and control room for researcher. It allows researchers to collect both gesture and sound data in addition to the eye movement data. Moreover, with the aid of the two moving camcorders which can rotate 360°, it is possible to track both mouse and keyboard activities of the participants. In this study, Tobii 1750 eye tracker device was used, and the data were analyzed with Clearview and Tobii Studio software. The participants were asked to sit at a predetermined distance which is approximately 60 cm from eye tracker and requested to keep this distance during the experiment as much as possible.

Figure 3.2 Human Computer Interaction Research and Application Laboratory

Before starting the experiment, participants' eye positions were calibrated by performing the calibration process with the help of eye-tracker. The participants' eye positions were calibrated by having them to look at the nine moving points on the screen. Calibration process is important for eye tracking studies since it enables eye tracker to have an idea about the each participants' eyes. In order to make an approximate judgment of the participant's gaze point, it is essential to actualize the calibration process (Tobii Software User Manual). A view from the eye tracker device is given in Figure 3.3 below.

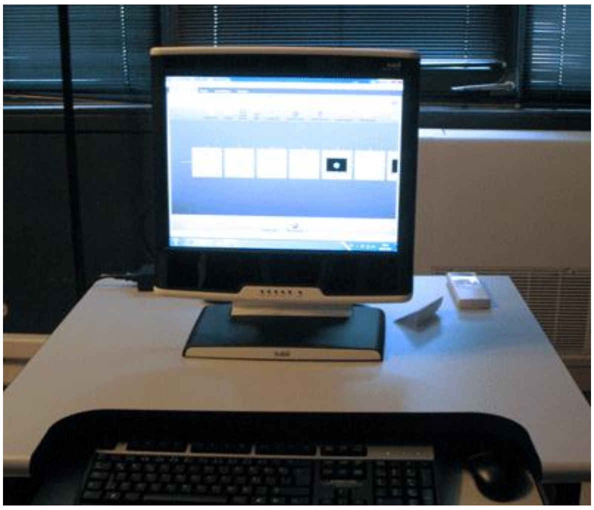


Figure 3.3 A screenshot from Tobii 1750 Eye Tracker Device

Eye tracking device allows researchers to have different stimulus types according to needs of their studies. In this study, the data consist of different dynamic pages which changes according to any insertion to the CM, thus the researcher used screen recording instead of the other available options (image recording, web, or pdf). In addition, analyzing the entire process is important for researcher in order to understand the potential patterns existing between the participants. Thus, the data analyzed holistically which is possible by using screen recording option. This eye tracking device and software provide a detailed picture regarding each participant's fixation duration (FC), visit duration (VD) and fixation count (FC).

Cmap Tool Environment

In this study, for developing CMs a free tool (Cmap Tool) was selected (cmap.ihmc.us/download). This tool enables users to develop CMs, navigate and share their knowledge structures by using this visual representation. In addition, it provides users to share their maps with other people by using the server and search relevant information for their CMs. A screenshot from the tool is given below (Figure 3.4).

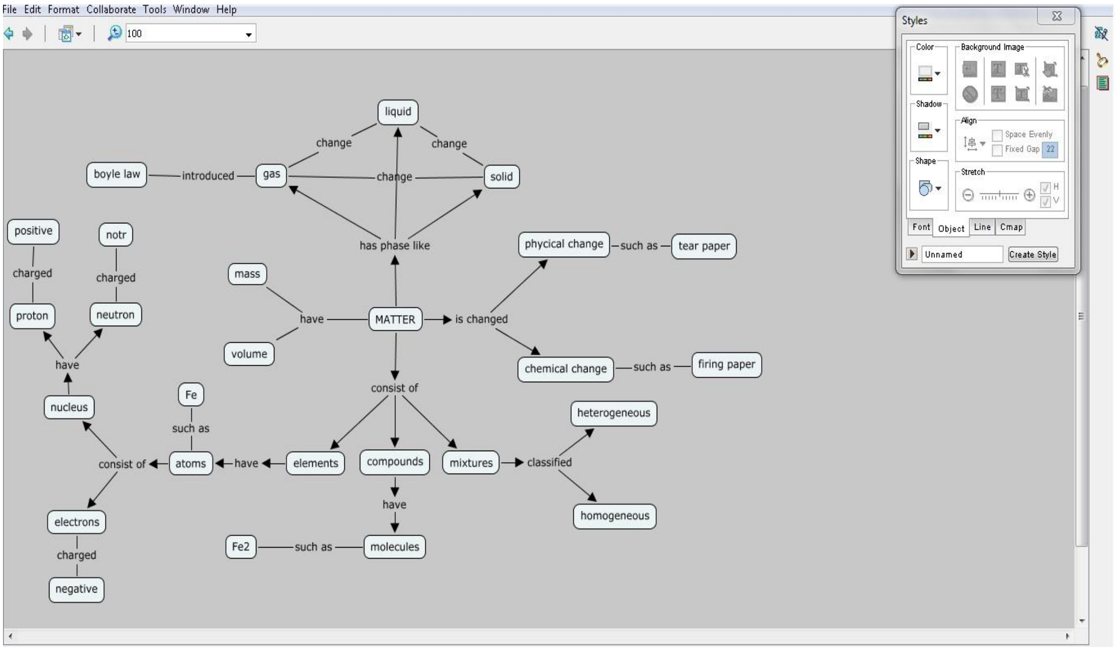


Figure 3.4 A Screenshot from Cmap Tool

The data collected through different instruments and equipments which were presented below.

1. In order to determine demographic information, the questions were asked through the verbal protocol.
2. The preferences and experiences related to the usage of CMs, kinds and usage were explored by asking open-ended questions in CM inventory generated by the researcher.
3. Eye movement data during the CM development process (VD, FD, and FC on the CM) were collected through the eye tracker device.
4. The cognitive process patterns during the CM construction were investigated through the open-ended questions related with the process and debriefing (verbal) protocols after the eye tracking sessions.

The study was administrated with the permission of METU Ethical Committee. They were informed about the confidentiality of the responses collected assured and acknowledged that the data will not be shared with third party. They were also informed about the aim and potential benefits and risk in this study and they are free to withdraw from the procedure at any time. All participants signed consent form about their voluntarily participation and sufficient introductory information related with the aim of the research. All the data collection process was conducted in METU HCI Research and Application Laboratory, Computer Center. Eye movements' of the participants were gathered by Tobii 1750 Eye tracker device and analyzed with the help of Clearview and Tobii Studio software.

Before the CM development process, pre-structured handouts for Cell and Matter topics (See Appendix E, F) were given to the participants to remind the subject. Since the students did not know which topic will be given for concept mapping beforehand, the researcher prepared a structured handout on the predetermined subject for participants. The main purpose for developing this kind of handout was to remind the participants about the subject matter briefly. The handouts were constructed by researcher by using the books being used in their subject matter teaching. Also they were checked by subject matter experts to prevent any misconception or inaccuracy about the information given. The participants allowed examining it without time limitation. However, during CM development process, they were not allowed to use handouts. They were just allowed only if they had problems about the dictation of some words.

3. 5 Procedures

Pilot Study

The pilot study consisted of a chain of steps that were explained respectively as training session, inventory, prior knowledge test and eye-tracking procedures. First of all, the participants were trained by the researcher for familiarizing them with both CMs and the software which was used in the study. The computer based software 'Cmap Tool', which is free to use (available at http://cmap.ihmc.us), used in laboratory conditions by the participants. The training lasted one lesson hour and the content consisted of what CM development is; its types and the design possibilities. It was essential for showing the individuals different kinds of CMs and their specialties, and also the tool was explained and they were allowed to use on one's own and exploring its features. Before the experiment, an inventory about the CM development and their background on CMs were given to the participants. In addition to this inventory, participants' prior knowledge about Cell concept was assessed by utilizing the CCT (See Appendix H).

After all these procedures, the participants were asked to develop their own CM on a specific Biology topic (Cell) which is pre-determined with the subject matter experts in terms of the penetration of the subject in Science and the possible familiarity of the participants. The Cell topic was especially chosen by one of the experts that it is an introduction subject and very common for students. Before starting the experiment, a structured handout on Cell subject (Appendix E) was given to the participants to remind the subject matter briefly. Then, they were allowed to start to prepare the CM on Cell. The CM development process was implemented by using an eye-tracking device. During the CM development process, the participants' eye movements, gestures and voices were recorded. This process is valuable since eye-tracking device has contribution to the analysis process by collecting data on eye-behaviors and enabling different analyses. All procedures in Pilot study were summarized in Figure 3.5.

Figure 3.5 Procedures in the Pilot Study

Main Study

Phase 1

Phase1 includes a new group of participants who were pre-service teachers. The same procedure was utilized but appending another procedure, writing an interpretative essay. This phase also included, training session, administrating an inventory, CCT, and interpretative essay instrument about the CM development process. In this phase, as a topic Cell was chosen from the field of Biology. Since the main purpose in this study is to comprehend the cognitive process more thoroughly, this requires an in depth analysis of CM formation and interpretative essay. For this reason, it is essential to obtain data from individuals on concept mapping process and their styles, preferences and ideas. Writing an essay is a helpful way to collect data from the individuals on their construction process with letting them to explain the process with using their own words. All procedures in Phase 1were summarized in Figure 3.6.

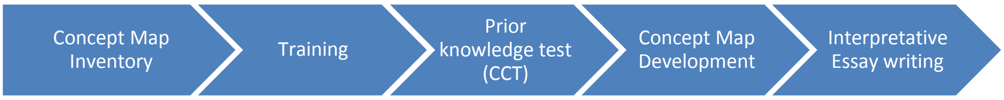


Figure 3.6 Procedures in Phase 1

Phase 2

The last phase of the main study was conducted with the same group pre-service teachers who developed CM on Cell subject of Phase1. The same procedures were applied, but another topic was chosen from Chemistry (Matter). In order to examine participants' prior knowledge on this topic, MCT was administered. Furthermore, unlike the first phase a retrospective review which is a debriefing strategy was administered. Retrospective review is a debriefing protocol similar to thinking aloud. However, the difference between these two protocols is that thinking aloud requires the participants speak about the process at the same time of the process, the other one is after the procedure. In retrospective review, the participants asked to watch the video recordings of their CM development process and talked about the process while answering the questions of the researcher about this process (See Appendix G). The main strength of this process is that the participant may easily remember the process because the video recording is a good reminder. In addition to the pre-service teachers group another group participated to the study who is subject matter experts in the field of Science Education. In this phase unlike the Phase 1, another topic was chosen (Matter) for CM development process in the field of Chemistry. Before starting the CM development process, participants' prior knowledge about Matter concept was assessed by utilizing the Matter Concept Test (MCT) (See Appendix I). All procedures in Phase 2 were summarized in Figure 3.7.

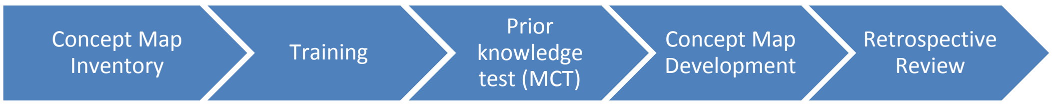


Figure 3.7 Procedures in Phase 2

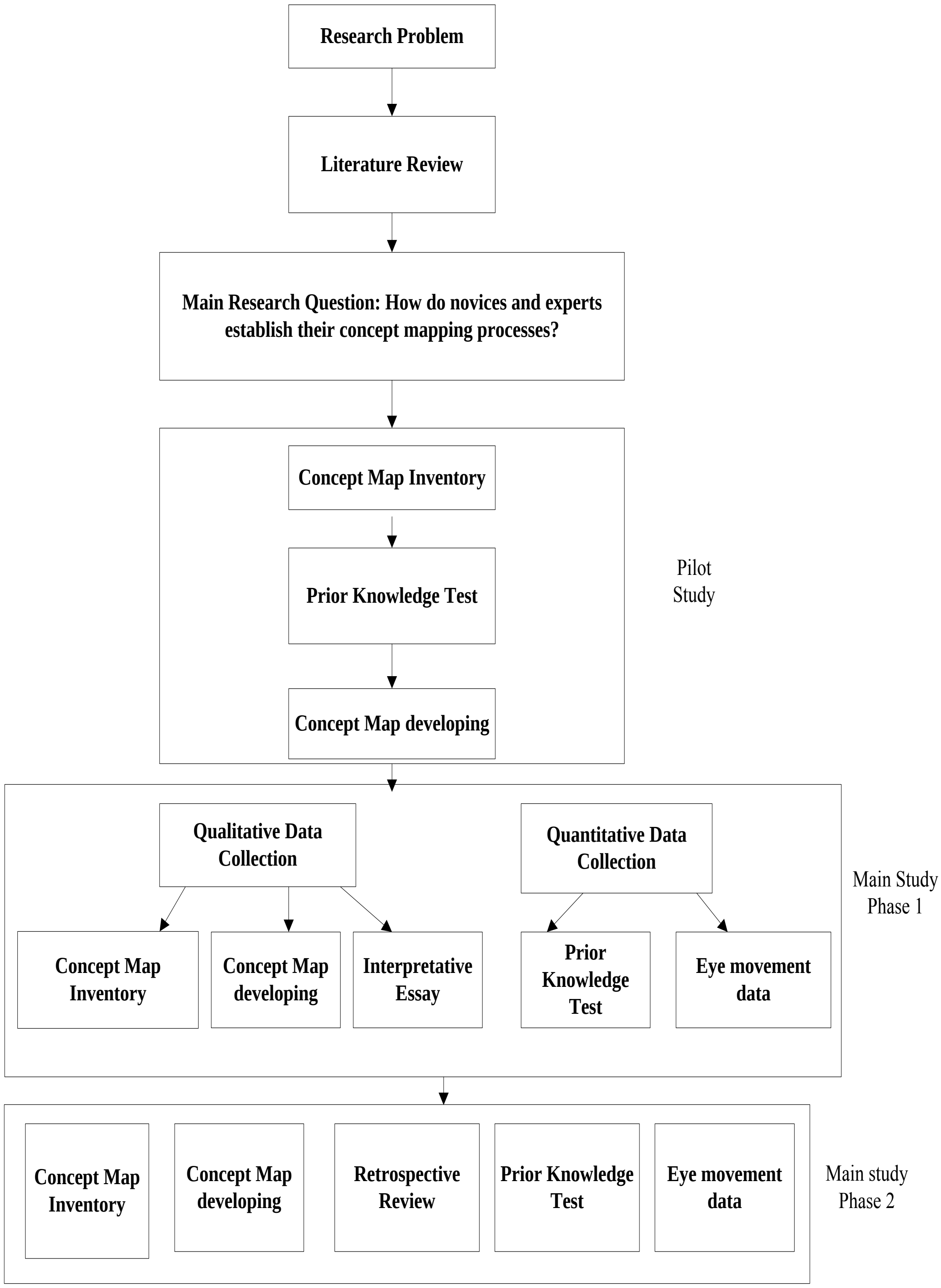


Figure 3.8 Summary of the Procedures in the Study

3.6 Data Analysis

In this study, data analysis part included from quantitative and qualitative parts. Bogdan and Biklen (2003) defined data analysis as "the process of systematically searching and arranging the interview transcripts, fieldnotes, and other materials that you accumulate to enable you to come up with findings" (p.147). According to Marshall and Rossman (2006) typical analytic procedures in data analysis include seven phases in it;

1) "Organizing the data
2) Immersion in the data
3) Generating categories through analytic memos
4) Searching for alternative understanding and
5) Writing the report or other format for presenting the study" (p.156).

The researcher is responsible in every phase for data reduction and managing the collected data into manageable pieces which aims to interpret the participants' acts to meaning (Marshall & Rossman, 2006). In this study, data analysis part included both qualitative and quantitative analysis, consisting of five parts in itself;

1. <u>Debriefing protocol analysis (Retrospective review):</u> The debriefing protocol sessions were recorded by using tape recorder and transcribed. The codes and themes were generated from the data and coded separately by two researchers and compared for ensuring the consistency as suggested by Patton (2002) for the analysis triangulation.

2. <u>Eye movement data analysis:</u> In the user manual of the TOBII eye tracking device, it is explained that determining Area of Interests (AOI) is a useful strategy for calculating the gaze data more easily and quickly. Eye-tracking device provides not only qualitative but also quantitative data to the researchers. The qualitative part consists of analyzing the gaze replays and

hot spot data. This process includes using special software to fragment the data into smaller and lucid pieces. While analyzing the gaze replays of the participants, the main aim was to recognize a specific pattern or any related clue on this process. The hotspot data was also essential for comprehending the process with considering the AOIs since the more focused areas were provided by the device. The qualitative parts included quantified eye movement data; fixation count, fixation duration, total visit duration.

3. Document analysis: This process includes synthesizing the written pieces from participants like interpretative essay questions and inventory on participants' prior experiences. In order to be ensuring about correctness and appropriateness, the data was typed up by researcher and checked whether it has some misconceptions or mistakes. In addition, the developed CMs were analyzed with respect to the content richness by using some criteria.

4. Descriptive analysis: The researcher analyzed the prior knowledge test scores and eye movement statistics as VD, FD, and FC. In addition, time spent for specific acts (e.g., concept construction, link development, writing, deleting, arrangement, and crosslink) were analyzed.

5. Progress pattern analysis: The researcher tried to reveal four periods during the CM development process while considering the progress as a basis. While determining these four periods; beginning, early mid, late-mid, and final periods, the researcher set the constructed concept number as a basis instead of setting the time. This phase determination was not depending on the time because the CM completion periods were ranging very different time periods. Setting the completed number of concepts lets researcher determining the progress without limiting with the time and observing the completion process in a continum. This analysis allowed researcher to determine the basic acts in these periods. The determined acts were given in Figure 3.9.

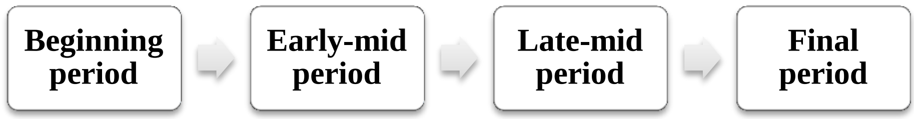


Figure 3.9 Concept Map Development Progress Periods

Transcribing speech between the researcher and participants was another challenge for researcher since some of the participants may not feel themselves comfortable enough to speak to a machine or did not speak understandable enough and this may produce problems for researcher especially after the recording. According to Tilley (2003) visual cues are important for interpreting the transcribes since they may include some important evidences on the participants' behavior which cannot be understood by just listening the audio (cited in Marshall & Rossman, 2006). This weakness of recording the participants' words is handled by using video recordings also, it enables researcher to interpret the visual clues from participants during the audio information analysis process.

In the data analysis process, the researcher first organized all the data, including the debriefing session between participants and researcher was transcribed and controlled whether there are some misunderstandings or incorrect transcribes. Then, the researcher typed up all the documents collected from participants and arranged into tables to have a better organization. In addition, the researcher generated the codes and themes gathered from the data after the data collected from debriefing sessions and document analysis. According to Marshall and Rossman (2006), analyzing data is a process which consist of generating categories and themes, involves exploring whether there is a pattern in participants' words or acts. It was also indicated by Patton (2002) that inductive analysis is being used by many researchers since they have a propensity to inductive analysis. In this study, the researcher used inductive analysis while generating categories and themes. Additionally, Strauss and Corbin (1990) identified three coding strategies as (1) codes, defined before the analysis, (2) codes gathered from the data, (3) coding in a general frame. Visual representations of the phases in the study were given in figure 3.10.

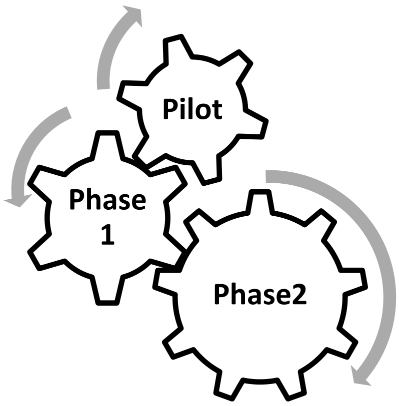


Figure 3.10 Visual Representations of the Phases

Qualitative Data Analysis

1. <u>Interpretative Essay Analysis</u>

The reflection is not a new term that especially in education, "concept of reflective practice" is known by the studies of Schön (1983, 1987 cited in Boud & Solomon, 2001). It is defined as "those intellectual and affective activities in which individuals engage to explore their experiences in order to lead to new understandings and appreciations" (Boud, Keogh, & Walker, 1985, p. 19). According to Schön (1983, 1987) reflection has a significant contribution to practitioners that it enable people to reflect their experiences and thoughts and learn from it (cited in Boud, & Solomon, 2001).

Moreover, in the literature there are many attempts to analyze the findings coming from the real experiences of the users. Such as, narrative analysis which is usually used in social sciences is a beneficial method for providing a view of the participant (Edgerton & Langness, 1974 cited in Marshall & Rossman, 1999). LaBoskey (1993) stated the importance of allowing pre-service teachers to 'embrace both practical and theoretical content' (p.34). Reflections are important in teacher education that it allows the pre-service teachers to bridge between theory and practice while assisting the critical evaluation and providing more active roles in the profession of teaching (Calderhead, 1988 cited in Bain, Ballantyne, Jan Packer & Mills, 1999).

Although in the literature there are many definitions and studies on reflections, journal writings, 'interpretative essay' term was chosen since it includes both narrating the experiences and contains the essays' nature in it. In this study there was a narrative explanation part which was given to the participants as a part of the experiment. The interpretative essay instrument consisted of open-ended questions related with their concept mapping process. The participants asked to explain their concept mapping process with the aid of the questions. The main reason for selecting this kind of activity was to enable the participants to explain the process in a narrative way. With this way the participants might be able to transfer their mind structure even they could not represent their map. Also, writing an interpretative essay might give them chance to explain the main reasons of their actions more easily and this may give clues on their knowledge structure.

For analyzing the interpretative essays and inventory responds content analysis technique was used. According to Marshall and Rossman (2006) content analysis is a process which includes analyzing any related documents for determining information. Also they stated that the main strength of content analysis is its comfortable nature for the participants. However, this comfortable nature of the technıque is also a disadvantage for the researcher. It is not very easy to make "inferential reasoning" from the data (p.108). In this study the main purpose of using content analysis was to provide information on the cognitive process without disturbing the participants. For this reason, the interpretative essays which were responded by the participant, analyzed with using content analysis technique. The codes and themes were emerged from the analysis were explained in the result section in detail.

Furthermore, participants' CMs were analyzed by a subject matter expert in order to determine their content richness. In the literature there are different approaches for quantifying and scoring CMs (Wandersee, 1992; Novak & Gowin, 1984), also in recent years several attempts have been observed as using computer based tools for scoring CMs (Taricani & Clariana, 2006). In this study, the expert used predetermined criteria from the literature (Trowbridge & Wandersee, 1998) for ensuring aa standard procedure for every map while analyzing. All CMs were analyzed by considering these measures and were scored with respect to these criteria (See Table 3.2.) .

Table 3.2. *Scoring Rubric for Concept Maps* (Reprinted from Trowbridge & Wandersee, 1998, p. 122)

1. Score 1 or 2 points for each meaningful and relevant propositions of **concept-linking word(s)** - concept. More precise propositions are to receive 2 points.
2. Score 5 points for **each valid level of hierarchy** shown on the map, provided the map is treelike and not linear.
3. Score 10 points for each **cross-link** that is both valid and significant. Score 2 points for a valid cross-link that does not indicate a synthesis between sets of related concepts or propositions
   Note: Cross-links may indicate creative thinking and care should be given to identify and reward those when present. A cross-link always bridges two distinct branches of a map.
4. **Examples** (specific events or objects that are valid instances of a concept) should be scored 1 point each (By themselves, these do not count as a level of hierarchy)

2. Debriefing Protocol

Since it was aimed to explore the cognitive schema of the participants during an action of development, narrative became an important component in this study. Perecman and Curran (2006) remarked that "the narrative may be taken as a marker of pattern of cognition and behavior totally different from that hypothesized in economics and in rational choice behavioral models more broadly" (p.153-154). In this study, the researcher first tried to use think aloud protocol for exploring how participants thinking during the CM development. However, this technique both has some strengths and weaknesses. According to Rubin and Chisnell (2008), although, think aloud protocol allows researcher flexibility apprehending participants' performance and choices, it may be still bizarre and disturbing for some of the participants. It might be necessary to persuade these kinds of participants for think aloud. In addition to this, they added the effect of think aloud protocol on participants' thought process as it decelerates the thought process and amplifies mindfulness. Lastly, "regardless of personal styles, preferences, and other considerations, it is just plain exhausting to verbalize one's thought process for very long" (Rubin & Chisnell, 2008, p.205).

The need for using debriefing technique is aroused because of the inefficacy of think aloud protocol and its weaknesses for this study. Although debriefing technique is usually used in usability testing, it suited to the needs of this study, perfectly. Rubin and Chisnell (2008) described debriefing as "exploring and reviewing the participant's actions during the performance portion of a usability test" (p.229). They also indicated that debriefing allows researcher to wrap up the data before participants leave. Furthermore, this technique enables participants to clarify the unseen points which could not seen by the researcher such as underlying thought of an accidently deleted file (Rubin & Chisnell, 2008).

The specific technique used in debriefing was replaying the test (sometimes known as retrospective review), which is a technique that allows participant to remember the action that she/he may easily forget (Rubin & Chisnell, 2008). In this study, the manual replay method was used for exploring the cognitive process with gathering information from the participants' themselves. It was explained by Rubin and Chisnell (2008) that it is a beneficial way for participants watching the video about their actions, since they may be able to bring thoughts of themselves better to mind.

3. Eye movement analysis

Acts Used While developing CMs (general)

Each participant's CM development process was analyzed with the aid of Tobii Studio software's AOI and scene tool features. In each video, some specific acts were observed frequently; mostly monitored acts were determined and labeled by the researcher. There were common acts which were observed both in Pilot study, and in the real study Phase 1 and Phase2. It was found that some acts included more than one action, these sub acts were also explained under the main action. These acts were also categorized under "scenes" which is a feature of Tobii Studio to categorize the eye movements for analyzing by grouping them under different AOIs. The descriptions of the behaviors and some of the representations related with these actions were given below. However, some of the actions could not be represented by using figures since they include series of acts inside which was not possible to represent by figures.

- Constructing a concept: This act starts with clicking twice to generate a blank concept and proceed with clicking twice inside of the concept box and then writing inside of the box. The act is a whole and the individual completed the act without stopping for another act. See figure 3.11 for the visual representation of the act.
-

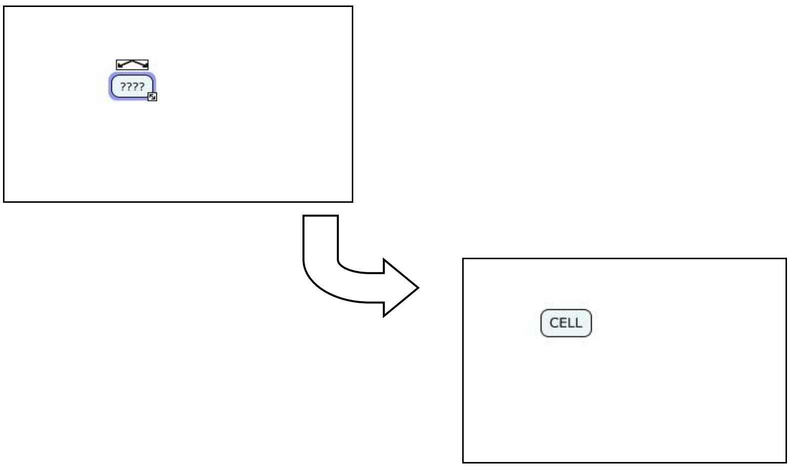


Figure 3. 11 Steps while constructing a concept

➢ <u>Constructing a blank concept:</u> This act is very similar to the "constructing concept", starts with clicking in a blank area and generating a blank concept. However it differs from constructing concept act as it proceed with writing into relation or any other act instead of writing into concept box. Because of this interruption within the action, it necessitates a different label.

➢ <u>Writing into a concept:</u> This act consisted of only filling a concept which is constructed before.

➢ <u>Constructing a link:</u> This action is very similar to concept construction. In order to write a link, first it is required to develop a concept and then by clicking the concept the arrow will be appeared. By dragging and dropping the arrow, a relation and another concept box will be appeared. In order to write inside the link box, it is necessary to click twice inside the box and write down the relation word. See figure 3.12 for the representation of the act.

Step1 **Step2** **Step3**

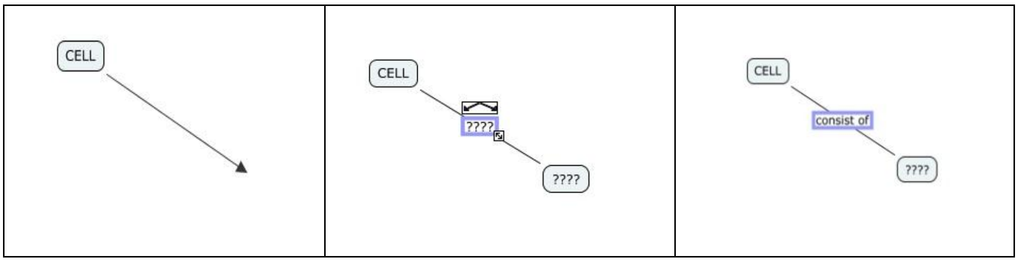
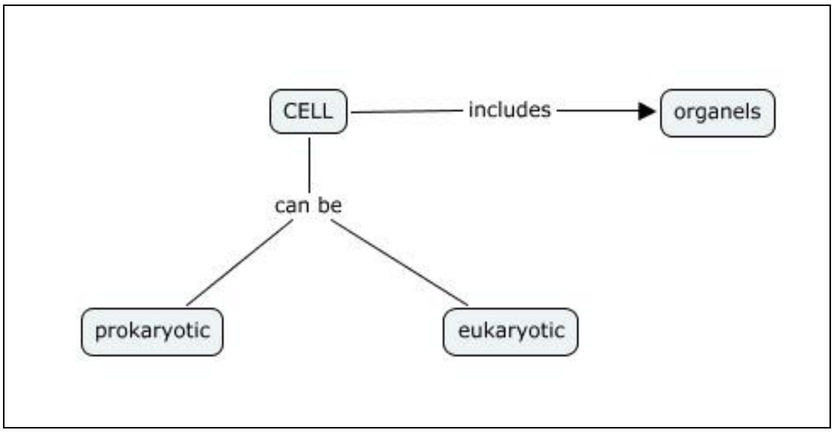


Figure 3. 12 Steps while constructing a link

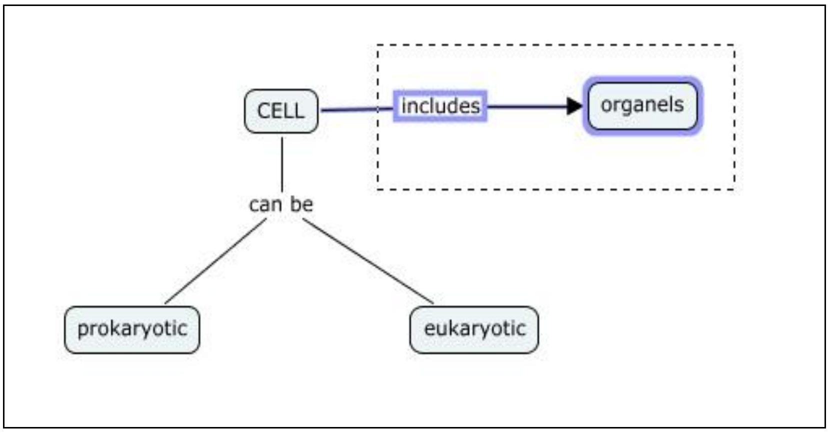
➢ <u>Erasing (Deletion):</u> This act consists of any movements for deleting either concept or relation. However, this activity may include steps like deleting both concept and relation or deleting a branch or cluster one time. Usually, this may be a result of recognizing inaccurate information in the map. For performing the act, it is required to choose the concept, link or the cluster of concept and relation, and then to use delete for erasing.

- *Erasing a concept:* It is an act that the individual just erases a specific concept. It may be related with finding a proper word on that concept or realizing the misspelling on that concept.
- *Erasing a relation*: The individual just erases a specific relation. The reasons may differ like finding a better representing word, or realizing the repetition of some relation words. Example: Realizing s/h used the word "consist of" many times as a relation word in the CM and decided to change some of them with "include" or some other suitable words.
- *Erasing a branch/ Erasing both concept and relation:* The individual sometimes deleted both concept and relation for writing something new or the same concept, relation to somewhere else. This is typically a result of being unsatisfied from the branch's positions or deciding a better position for it.

Step1



Step2



Step 3

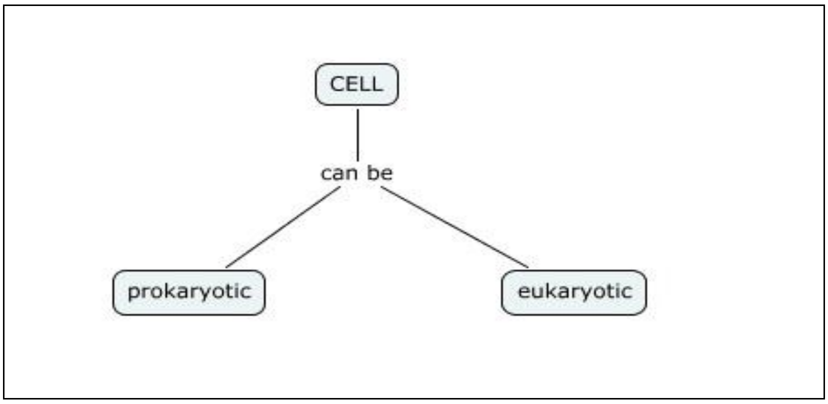


Figure 3.13 Steps while erasing a concept or link

- Arrangement: This act is related with arranging the places of the concepts, relations and branches. It includes actions like changing the places of either concepts or links by reason of having more spaces for other concepts or adding more information to that place. Placement is generally based on the attempts to include as many as concepts or relations in one page representation. Representing the knowledge and trying to fit one page CM brings an arrangement and organization problem. For that reason many participants made several attempts for better organizing their knowledge and arrangements during their CM development process.

- Reasoning: This act is one of the most important acts for this study in CM development process. Although, CM development process could be seen as a whole process includes reasoning and problem solving in every stage, the researcher tried to categorize the specific time periods for reasoning with the aid of eye movements. This act includes a thinking process and usually continues with another act like constructing a new concept, writing into concept and relation, constructing a cross-link, deleting something or adding into concepts or relations. The individuals had a reasoning process during the CM development, which could be easily captured by observing the eye tracking process. This process also includes a controlling and checking process that could be a different act under the reasoning act.
    - Controlling and checking: This act consist of movements for checking the concepts for errord and links swiftly to control their accuracy. This act has a different point than the reasoning process. In reasoning act participant proceeds with specific acts, like developing a new concept, writing into a new relation, or constructing cross-links. However, after controlling and checking action, usually it is not expected to observe newly formed concept or relation, this act proceed either with revision, arrangement or using toolbox which means adjusting the map instead of developing new concepts or links. During this act, eye movements are fast and result with either no movement like constructing a new thing or just correction if necessary.
    - Scrolling: This is an act which consist of scrolling throughout the CM for a controlling the information. This act can be considered as a simultaneous act for controlling checking act.
- Fixing concept/ relation (Revising): During CM development process, many participants made either grammatical or semantic mistakes. Usually, the participants made typing errors or realized them after a while. This process called ‘fixing or revising’ since many participants tried to fix the mistakes they realized by correcting the word or adding some words to the concept or

relation words. Sometimes, they decide to use a phrase or better word and add some words to existing word.

- Crosslink: Developing a meaningful relation between two different branches is defined as crosslink. In this act, it is required to construct a meaningful relation and between two different branches. See Figure 3.14 for a hotspot view for a crosslink act.

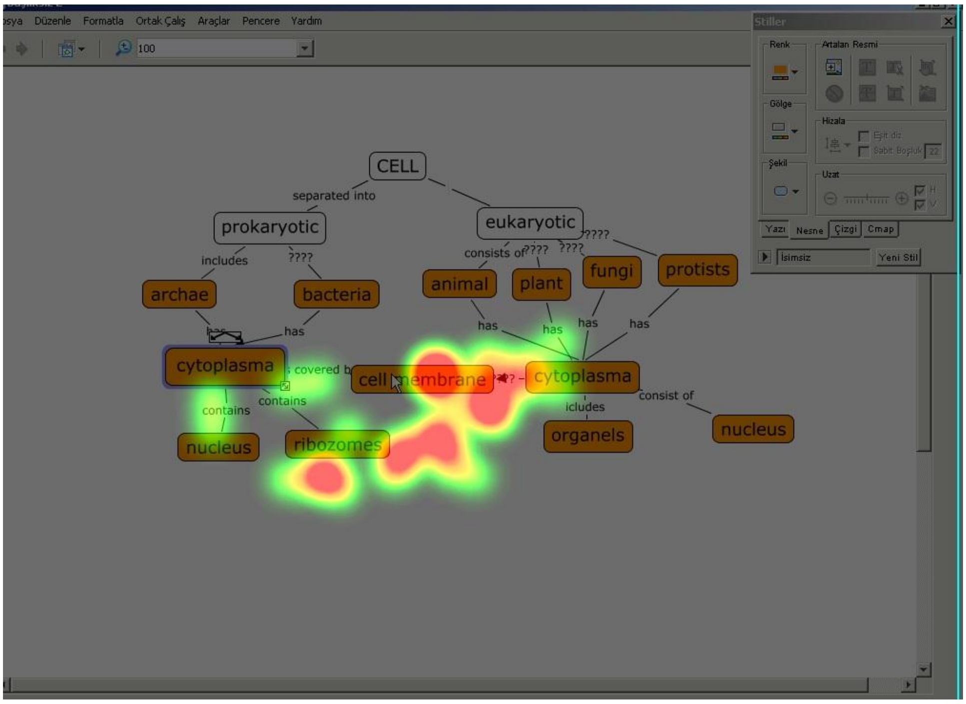


Figure 3.14 A hotspot view for cross-link act

- Tool box usage: The tool includes a toolbox inside and users have chance to change their maps' appearance. The act is related with using this tool box for different purposes like, changing the arrow way, changing the color, changing the box style, changing the font style or size. See figure 3.15 for a hotspot view for toolbox usage act.

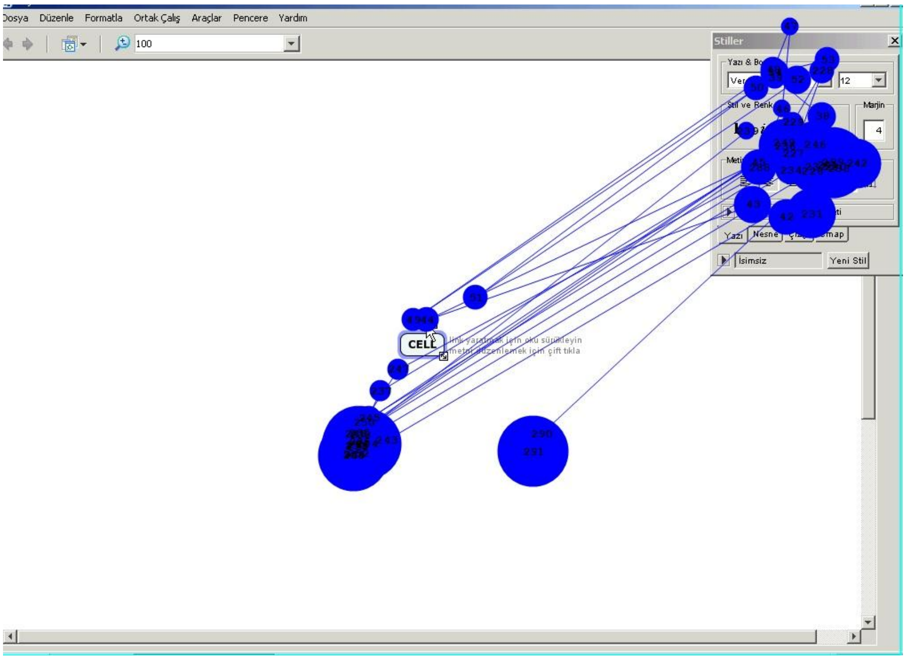


Figure 3.15 A gazeplot view for tool box usage act

- Placing tool box: This act related with the placement of the tool box. Some of the participants tried to fit the map into ne page and tried to write some concepts and relations on the place of toolbox, so they changed the place of it.

- Short cut usage (Ctrl+C, V, X, Z): This act includes using the short cut of the some acts like copy, paste, taking back the previous act, zooming in or out to the screen. Since, this is a repetitive act between many participants; it is labeled as short cut usage.

Each participant's data were analyzed by using these acts as the reference point while dividing into segments. Since the researcher determined these frequently observed acts by herself, it was required to check the accuracy. For that reason, she asked a subject matter expert and member's help for checking the accuracy of her labeling and the agreement of categorization. However, coding every recording took fairly long time and it was not feasible to check the entire recordings by either an expert or another member. Thus, to validate the determined acts by the researcher, a subject matter expert's help was asked. They went through three participants' recordings together. The researcher selected the acts randomly and asked expert's definition about the selected acts to check the accuracy of the determined acts. For each act the the researcher asked expert's categorization and labeling about the observed act. Both categorizations and labeling of the researcher and expert were compared to check the consistency. Almost all act categorizations were matched. Additionally, the researcher asked another member to go through on 10 % of the dataset. The agreement on the act names and determination was coherent. Furthermore, the verbal data was used to check the agreement between participants' own determination and researchers' categories.

Quantitative analysis

Quantitative analysis consist of analyzing prior knowledge test of the participants and the data coming from eye-tracking device which is mostly descriptive, FC, FD and VD values. TOBII Studio software enables researcher to analyze the video data and translate eye behavior data into numeric format by using AOI tool. The researcher analyzed the data by using this tool and obtained descriptive data about the eye behavior of the participants. SPSS 20 was used for analyzing the descriptive data. Since the researcher is not an expert in both Biology and Chemistry fields, assistance from the experts in these fields were taken and the key for prior knowledge test was developed and the scores of the participants were calculated by using this key. Furthermore, the participants who developed in both subjects were compared to see the subject matter effect and whether there were differences between them according to the eye movements and quality of the map. In order to compare the participants non-parametric analysis techniques were used.

3.7 Researcher's Role

According to Marshall and Rossman (2006), "in qualitative studies, the researcher is the instrument" (p.72). This view also shared by Rossman and Rallis (2003) that, they explained the importance of researcher's role as "researcher herself is critically important in conducting the study because the researcher enters the world of the participants, she may shape that world in significant way" (p.10).

The researcher got her BS degree from the department of Computer Education and Instructional Technology at Ankara University. After the graduation she worked as a Computer Teacher in an elementary school and she had experienced about the field first hand. This experience means a lot for her but she desired to have experiences in both research and teaching in the field of Instructional Technology. Therefore, she started her PhD at the department of Computer Education and Instructional Technology METU. She also worked as a research assistant in the same department for five years. In terms of teaching experience, she took place in both field and academy. In addition to this, she has involved courses as an instructor during her PhD education. Although, she did not work in Cognitive Science field directly, during her PhD and visitor scholar period in US, she has encountered with many source related with this field. The expertise of her advisor also helped to understand the cognitive process of human beings. Moreover, she worked as a researcher in the HCI Laboratory and she has taken part of many studies about human computer interaction field especially studies considering the issues related with Instructional Technology. She has an expertise in using eye-tracking device because of her four year experience with this device. She has both practical and theoretical experiences this helped her to construct the study in every phase.

As a researcher, she has a flexible nature about different paradigms and she believed that every paradigm has its strengths and weaknesses in it. She believes that it is necessary to discover the best combination of different paradigms and their techniques for questioning her own understanding. In this study, she has used primarily qualitative approach because of two reasons; firstly she has more experienced to collect qualitative data and she has strong verbal skills, secondly, exploring cognitive process involve rich and depth information. Despite these reasons, the researcher is aware of the fact that, generalization of the results and understandings is a common problem for qualitative research. People use their words for communicating each other and science use numbers for the same purpose. For that reason she believed that transforming verbal data into numerical format may enable the results be understood by many people easily. Thus, she used descriptive methods for representing the data which is incontestable among many quantitative researchers. During the data collection, she has sometimes struggled about choosing the best technique for gathering data from the participants. Sometimes she has been so upset about the setbacks in the data collection process. In the first and second studies, she could not gather clues on the cognitive process of the participants and she tried to found new techniques for gathering information. This is a suffering process because of the blurry structure of human thinking. In order to handle this, she tried to collect various data and tried to comprehend them under a broad perspective which comprises different approaches. However, she realized that each study has its own unique contribution to the other study. She has an understanding about the other phase and has different paths about finding the truth.

3.8 Trustworthiness

In qualitative research studies distinct than quantitative research studies, another term is being used for encompassing the terms validity and reliability. Trustworthiness matter critical importance in qualitative research studies since it assure the quality directly. Guba and Lincoln (1985) expressed four strategies for ensuring trustworthiness in a qualitative research:

1) Credibility
2) Conformability (or neutrality)

3) Dependability (or consistency)
4) Transferability (or applicability) (cited in Golafshani, 2003).

Many of strategies were also advised to establish the trustworthiness in a qualitative research study (Creswell & Miller, 2000; Golafshani, 2003).

- The existence of the researcher: The researcher's role in this study was explained under the related part on methodology section. This kind of information may be helpful to other researchers who are willing to conduct related studies.
- Presenting the data collection and analysis process in detail: The data collection process and the stages in this process were explained in the related section in depth. In addition to this, data analysis process and the techniques were used also clarified by researcher. Moreover, expressive explanation of interviews and document analysis were presented by researcher to make sure that other researchers and readers can understand the process and increase the probability of replicating the study in other contexts.
- Recording the data mechanically: One of the validity threats in qualitative researches is the description of the data since researcher may have problems on remembering the information gathered from the participants and there are always possibilities to occur some kind of inaccuracies in research studies (Maxwell, 1996). For overcoming this threat the process was recorded by using both video during the eye-tracking data collection part and tape-recorder for interview sessions.
- Constructing Triangulation by collecting different types of data and using different methods: Triangulation is a common way for validating credibility in qualitative studies (Golafshani, 2003, Yıldırım & Şimşek, 2008). This process is defined by Maxwell (1996) that as a process which aims to provide information from different data sources, groups, settings or using diverse methods for determining. This view is shared by Denzin and Lincoln (2005) they explained it as 'triangulation has been generally considered a process of

using multiple perceptions to clarify meaning, verifying the repeatability of an observation or interpretation' (p.454). In this study, the researcher collected various types of data from participants; verbal protocols data, documental data, observation data and eye-tracking data were collected. These four types of data collected from novice and expert participants were used in the analysis process. The various data type (Verbal, document, observation and eye tracking data) enables researcher to assure the triangulation of sources. In addition to triangulation of data sources, both quantitative and qualitative methods were used for eliminating the deficiencies of both methods. This process is also called by Frankel and Wallen (2005) as triangulation which aims to support a conclusion with number of diverse instruments, hence the validity will be provided.

- Validity and reliability: These issues have critical importance in a research study that they always need to be carefully considered by the researcher by handling with the suitable methods. Validity is defined as a term 'referring the appropriateness, correctness, meaningfulness and usefulness of the specific inferences of the researchers make based on the data they collected (Frankel, Wallen & Hyun, 2012). Although these terms are considered applicable for quantitative research but the applicability of these types of validity in qualitative and mixed method research has being discussed (Johnson & Christiensen, 2004; Tashakkori & Teddlie, 2003).

- *External Validity:* Marshall and Rossman (2006) mentioned the problematic nature of the qualitative studies in terms of their transferanbility and generalizability to other situations. Generalization of the results to other settings is also known as external validity (Yin, 2009; Frankel & Wallen, 2005; Marshall & Rossman, 2006). Yin (2009) also explained the importance of external validity as a result of the concerns focusing on the weakness of generalizing issue in case studies. Marshall and Rossman (2006) explained that it is possible for qualitative studies by referring back to the theoretical framework or triangulating the data with multiple sources. Marshall and Rossman (2006) also added that, including multiple cases in a design would allow multiple sources and different data gathering techniques which would reinforce the usefulness of the study for other situations. In this study, because of the small sampling number generalizability is a concern for the researcher. However, in order to handle this issue, data collected from multiple sources to triangulate the data.

Internal Validity: In order to minimize the threats to internal validity; like instrumentation, attitude and researcher bias, standardizing the settings and data collection methods will help to control. In addition, gathering more information from the participants will help to control the subject characteristics and mortality threats (Frankel & Wallen, 2011). In this study, in order to minimize these threats the settings and the data collection methods settled. Furthermore, data collected from different data sources to minimize the subject characteristic effect and possible mortality threat. Moreover, the raw data were coded by the researcher twice at different times to check the consistency between the codes and themes. The codes and themes showed a parallel manner, but the second coding phase enabled researcher to include more details than the first coding phase. Peer examination is another process is used in this study to ensure the internal validity (Creswell, 2007). The researcher explained the study in detail including the aim, data collection, analysis process to one of her colleague who has a PhD degree at the Instructional Technology field. She has experiences on qualitative research studies and qualified the issues in our field. The raw data, generated codes and themes were reviewed by her and discussed with the researcher to check the consistency. Inter-rater reliability: The researcher asked one of her colleague to re-code a part of the data to compare the generated codes and themes to ensure the consistency in findings. The agreement score was .87.

Furthermore, since the coding the recordings took considerably long time it was not feasible to ask another colleaque to code every recording for determining the accuracy of the acts. However in order to validate the determined acts (controlling and checking, reasoning, constructing a concept, eg.), the researcher asked a subject matter expert's and a peer's help for checking the agreement accuracy on the act categorization. During the process, first the researcher and subject matter expert went through 3 recordings, and checked every specified act randomly for the consistency. Almost all act categorizations were matched. Additionally, the same procedure repeated with a member, they went through on 10 % of the dataset. The agreement on the defined acts was coherent. The verbal data gathered from the participants also indicated that the researcher's categorizations validated by their own statements.

Particularly, qualitative studies are much more dependent on the researchers' perspectives and open to biases (Frankel & Wallen, 2005). Lecompte (1987) supported this idea in qualitative studies, "researchers are concerned with the effect that their own subjectivity may have on the data and papers they produce (cited in Bogdan and Biklen, 2003, p.33). This issue was explained under researcher's role section.

Reliability is another critical component for a qualitative research study. Frankel, Wallen and Hyun (2012) described reliability as the consistency of results of an instrument over time, place and situation. For reliability in case studies, Yin (2009) suggested to "make as many steps as operational as possible and conduct research as if someone were always looking over your shoulder" (p.45). For this reason, the researcher tried to make the steps in data collection and analysis set as much as possible. Thus, it is essential for researchers need to be sure about their perceptions in the process and use different techniques for providing reliability. Furthermore, the researcher explored whether the CM development process affected from the subject matter change to check the reliability of the method. In order to validate whether the pattern among participants during CM development differed with respect to the change in subject matter, a group of participants asked to develop CM in two different topics in Biology (Cell) and Chemistry (Matter) and they were compared. The detailed information is provided in the Results section. For the summary of the validity and reliability issues see Table 3.3.

Table 3.3. *Summary of the Validity and Reliability Strategies*

Procedures	**Criteria**	**Strategy**
1. Prior Knowledge Tests		
1.1 MCT	1.1.1 Content Validity	The content validity of the test was ensured in another dissertation. The prior knowledge test was examined by not only a group of expert teachers but also the course teacher for the appropriateness of the items.
	1.1.2 Reliability	The relibability of the test was .79.
1.2 CCT	1.2.1 Content validity	The content validity of the prior knowledge test was examined by the subject matter experts.
2. Written Data		
2.1 CM Inventory	2.1.1 Content Validity	The content validity of the CM inventory was examined by a subject matter expert.
2.2 Interpretative Essay	2.2.1 Content Validity	Pilot studies were conducted. Then, the questions were revised with respect to the pilot studies. The content validity of the interpretative essay questions was examined by a subject matter expert.
3. Retrospective Review Protocols	3.1 Credibility	Pilot interviews were conducted. The participants were interviewed by the same interviewee at the same location.
	3.2 Dependability	The codes and themes table was checked by another peer. The retrospective review questions were re-structured after the pilot studies. The verbal protocols were recorded by a tape recorder to prevent potential problems on remembering the information gathered.

Table 3.3 (continued)

Procedures	Criteria	Strategy
3. Retrospective Review Protocols	3.3 Internal validity	The raw data were coded by the researcher twice at different times to check the consistency among the codes and themes and these codes were checked by another peer. Inter-rater relibility: The agreement score between the researcher and peer was .87. The same environment was used for data collection and the standardized procedures were administered. The researcher coded the entire recordings and second coder coded 10% of the dataset. Furthermore, an expert checked the consistency in determined categories and codings in random recordings.
	4.2 Triangulation	The eye behavior data were supported with the verbal and written data results.
4. CM Quality Analysis	5.1 Dependability	The CM quality criteria were composed from the existing literature.
	5.2 Conformability	Subject matter experts analyzed the CMs.

3.9 Ethical Issues

Ethical issues have significant importance since the inquiry is based on human beings and their words or behaviors. Three ethical issues in qualitative studies were explained by Frankel and Wallen (2005). First of all, in qualitative studies privacy is a critical component; in this study the participants' privacy and information collected from them are constantly preserved. The researcher need to be sure that process would not make uncomfortable and damage them. For providing this, the researcher first applied to Ethical Committee in her university to make sure that any of the procedure is harmful for participants. Afterwards, for protecting the privacy and their identity, the researcher provided a form to participants explaining the aim of the study and process. She also explained the data and any identity information will not be distributed. The researcher also needs to give choice participants for proceeding. In this study, the researcher informed the participants before the study that they can leave if they felt themselves uncomfortable about anything. In addition to this, the importance of being honest to participants especially about existing the recording like tape or video recorders also indicated by Frankel and Wallen (2005). In order to do this, the researcher asked to the participants whether the recording disturb them or not, and after that she explained that the process will be recorded by using both tape and video recorder. Secondly, the researcher need to be sure that the participants will not have any physical or psychological harm by the third party. This data just were used in this study for scientific purposes. Thirdly, the researcher needs to be careful about the possibility of deception. It is necessary to choose methods which do not require deception; this will decrease not only the trust to the researchers and but also the reliable knowledge opportunity.

3.10 Limitations

Case studies are common between researchers in the field of Instructional Technology because of its unique structure to provide in depth and detailed information about a bounded system or combination of systems. However, these types of studies generally have a generalization problem like in this study. In this study the main limitation was based on the small sample size and its lack of demographic diversity. However, since nature of eye tracking data was very robust the sample size for the eye tracking method was sufficient to make generalizations. In addition, the participants were consisting of only English language teaching faculty students which is limited to a small population in Turkey. In order to have a diverse perspective and observe the potential pattern among them, it is required to collect data from different universities and different faculties by increasing the sample size.

Another limitation was related with the generalization issue using convenience sampling as a sampling technique. Although advantages of convenience sampling exist, there are also disadvantages like its open to bias and also it is hard to generalize to the population (Frankel & Wallen, 2005). However, the reason for choosing purposeful sampling and convenience sampling was that, the necessity of having the basic knowledge on science (Chemistry, Biology) subject and related concepts and requirements of eye-tracking device. The reason for choosing convenience sampling technique for this study was related with the sampling limitation and the requirements of using eye-tracking device. The participants were a specific group from the same university. There are other participants who were from other universities and meeting the criteria of being participant. However, eye tracking device require a specific environment for collecting data and it was not feasible to bring all other possible participants to METU every time in terms of cost efficiency and management problems. For this reason, participants in this study selected studying in the same campus. In addition, the generalization issue related with the language issue is a limitation for this study. The participants were consisting of only English language teaching faculty students and hard to generalize the other institutions teaching in Turkish. Moreover, finding large number of experts who will be able to attend the study meeting the criteria is another limitation for the researcher.

Furthermore, losing data was another limitation for this study. Developing a CM from the very beginning instead of filling or evaluating a map requires a long period. Many participants were exhausted because of this extended CM development process. Especially, some of the participants were attended the study in both phases and this process frustrated them drastically. Hence, some of the participants were not willing to participate to the eye tracking session. For that reason, the attendance rate was lower than the researcher expected in the last phase. This is the common reason for data lose. In total 44 participants were attended to the study, but 9 of them were excluded because of the poor data quality of the recordings. Although they completed the CM development process successfully, their eye movements were not sufficient that sampling quality was under 50% to be considered in the analysis process. The quality of eye movement explained in Tobii Studio Manual as ‘50% percentage means that “one eye was not found for the full recording or both eyes during half of the time”. This is usually related with the participants’ looking away screen behavior. This might be related with the long data collection and their tendency to think without looking at the screen. Moreover, the limited number of the participants and the imparity among the groups prevented the inferential statistics which could reveal the mean difference between expert and novice participants statistically.

In addition to generalization issue, another limitation is related with the nature of the data in this study. Since the data coming from human beings, the researcher is dependent on the participants’ discourse in disclosing the process and inference about their behaviors. It is essential to make sure that the participants were answered the questions and verbalize their feelings honestly, otherwise it may be considered as a limitation for the study.

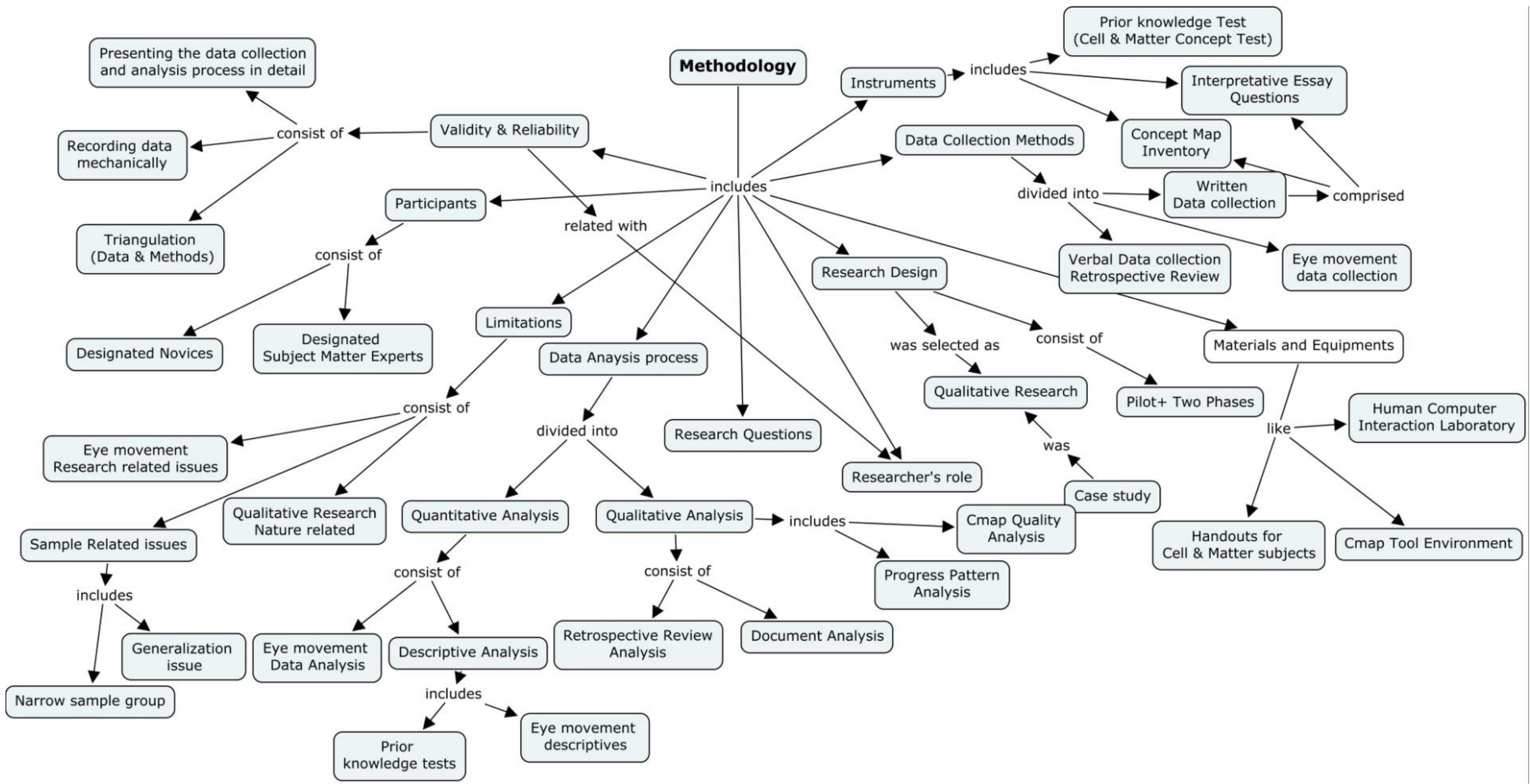


Figure 3.16 Summary of the Methodology

CHAPTER 5

RESULTS

This chapter presents the findings of the forementioned research questions. Firstly, the demographic information of participants; participant number for each phase, ages, backgrounds, CM development history (number of CMs developed, their kinds, and content chosen) and thoughts on CM usage were introduced as descriptive information by using an open-ended questionnaire. It was aimed to show the whole picture on concept mapping and the subsequent cognitive process of participants. Secondly, eye tracking behavior of the participants (VD, FD and FC), interpretative essay responses and retrospective review data were explored. Eye movement videos were analyzed frame by frame and quantified by classification of the behaviors into different categories. Lastly, all of the results were consolidated under a separate section. In this section, common themes, existing patterns, classifications and categorizations regarding the behaviors and within groups were identified.

4.1 Demographics

Demographic information of the participants is essential information that may affect the results directly. Thus for each cases demographic information of participants were gathered by open ended questionnaires (see Appendix C, D). Age, gender, educational background and CM development history (number of CM developed, their kinds, and subject chosen) of the participants and their opinions on CM usage were examined. The study includes 2 phases and in total 35 unique individuals participated. 15 of the participants participated in both Phase1 and Phase2.

In these two phases of the main study, 35 unique individuals participated while 30 of them were female and 5 participants male. The distribution of the participants according to cases:

Main Study

Phase 1: In this phase, 12 unique novice (pre-service teachers) participants, 9 female and 3 male participants participated to the study. Their ages were in a range of 21 to 23 years.

Phase 2: The second phase consisted of two groups of participants; novices (pre-service teachers) and experts (subject matter experts). 17 participants were participated to this phase, 1 male and 16 female. Although the participants number was higher, due to the eye movement quality 8 female participants excluded since their eye movement quality were lower than the required which means the eye tracker only caught one eye successfully and this may change the results. For that reason, they were excluded from the data. In addition to this group, another group of participants participated to the study as experts. This group consists of 6 participants, 5 female and 1 male participant joined to the study. 1 participant excluded due to the eye movement quality requirement. The first group's ages were in a range of 21 to 25 years and the second group's ages were in a range of 30 to 45 years of age. See Table 4.1.

Table 4. 1 *Demographics of the Participants*

	Phases	Subject	Gender Female	Male	Total
Novice	1	Cell	9	3	12
	2	Matter	16	1	17
	Total		25	4	29
Expert	1	Cell	3	0	3
	2	Matter	2	1	3
	Total		5	1	6

4.1.1 Educational Background

All participants were from science education background including both the novices and experts. In the pilot study, participants who were last year students at science related departments participated. In the main study (Phase 1 and Phase 2), the participants contributed the study twice both in third year and fourth year of their education. Their backgrounds were similar to the pilot study group as science education. The expert group selected as subject matter experts in their field. They have at least 5 years experience in science education field and concept mapping, and have PhD or MS degree from science education field.

4.1.2 Prior Knowledge on Subject Matter and CM Development

In order to examine whether participants had a required prior knowledge before the CM development process, prior knowledge tests (see Appendix H, I) for each subject were administered. In addition, in order to have an understanding on participants' experiences and views on CM development process, an inventory consisting of 9 open-ended questions were administered (see Appendix C). The underlying reasons for gathering data from participants about their experiences and views on CM were having a better understanding on their CM development process and determining other potential factors that may affect this process. According to the prior knowledge tests results, participants had the required prior knowledge to handle the CM development process in both subjects. The analysis showed that participants' average scores were quite high in both CCT (*M*=12.25, *SD*=1.82; Min=9, Max=14) and MCT (*M*=19.71, *SD*=1.90; Min=15, Max=22). See table 4.2.

Table 4. 2 *Prior Knowledge Test Scores for Different Subject Matters*

	N	*M*	*SD*	Min	Max
Cell prior knowledge test	12	12.25	1.82	9	14
Matter prior knowledge test	17	19.71	1.90	15	22

Participants' responses on the number and types of CMs they had developed were in a range of 1 and 15. Only 3 participants indicated that they did not develop any CM before this study while 1 participant did not give a specific number just mentioned. See table 4.3.

Table 4.3 *Number of Concept Maps Developed*

Measure	*N*	*M*	*SD*	Min	Max
Number of concept maps	29	5.2	3.70	1	15

To examine the participants' prior experiences on CM regarding different subject matters, their prior experiences were asked. According to their responses, they have developed CMs mostly on Science related subjects (N=12). Specifically they expressed their experiences on Biology, Physics and Chemistry subjects for CM development. In addition, some of the participants (N=8) declared that they have developed CMs on education related subjects including methods of education and classroom management while some of them (N=7) experienced both science and education related subjects. A few participants (N=2) did not share their experiences on CM development. See Table 4.4.

Table 4. 4 *Participants' CM Development Experiences on Different Subject Matters*

Subject Matters	F	%
Science Related	12	41
Education	8	28
Both	7	24
None	2	7

Since the participants were pre-service teachers and might use CMs in their active teaching life, their preferences on the most suitable subject areas for CM development and reasons for these preferences were asked. The results showed that, their preferences for the suitability of subjects are similar to their prior experiences. Likewise they experienced, majority of the participants (N=18) expressed the appropriateness of science related subjects for CM development. Additionally, social science subjects (N=10) are secondary mentioned and preferred subject area by the participants. Although many participants (N=12) experienced CM in the field of education (e.g. teaching methods), a few participants (N=2) indicated education specifically as a preferred area for CM development. Other subjects were mentioned by some participants (N=3); language teaching and only 1 participant indicated that CMs could be used for every topic (Table 4.5).

Table 4. 5 *Preferences of Participants on Most Suitable Subject Areas for CM*

Suitable Subject Areas	F	%
Science Related	18	45
Social Sciences	10	25
Education	3	7.5
Other areas	3	7.5
NA	6	15

This might be related to the participants' consideration about science education issues under the science related subjects instead of categorizing them under education subject. Other potential fields expressed by some participants (N=3) as, orienting new coming staff, language learning and other complex subjects. Furthermore, in order to explore why they find these content areas more preferable for CM development, the reasons lying beneath were asked. The apparent reasons for preferring science and social science related subjects directly associated with the nature of the subjects that could comprise rich amount of concepts (N=7). Some participants (N=4) also uttered that it is easy to represent the complex relations clearly and easily. The reasons for choosing specific areas were explained by some of the participants as;

> 'Biology related subjects are the most suitable subjects for CM development, but I think Physics and Chemistry could also be productive. Biology includes complex and more detailed information and the importance of making connections between the information differentiates it than the other subject areas. However, concept maps need to be used also in other areas to see the relations between the information.' (Novice2)

> 'Biyoloji konuları bence en uygun olan ama fizik ve kimya için de verimli olacağını düşünüyorum. Biyolojide daha karmaşık ve fazla ayrıntılı bilgiler olması ve bilgiler arası bağlantı kurulmasının çok önemli olması onu diğer alanlardan farklı kılıyor. Ancak, diğer alanlarda da, bilgiler arası bağlantı ve ilişkiyi görmek amacıyla kavram haritası kullanılmalıdır.'

> ‘Biology is a very suitable subject area for concept mapping, since it includes many concepts, and constructing relations among these concepts very important for meaningful learning. ’ (Novice3)
>
> ‘Biyoloji, çok fazla terim içerdiği ve tüm terimlerin ilişkilendirilmesi anlamlı öğrenme için önemli olduğundan kavram haritası kullanımına çok uygun.’

Participants (N=7) also expressed that CMs have potential to increase the memorability and comprehensibility of the subject. Some of the participants (N=5) explained the advantage of visual representation of the content and ease of association by CMs. Other participants (N=9) did not report their reasons for preferring these areas.

Additionally, participants were asked about their views on the types of CMs before this study, to explore their prior experiences. The responses showed that three main categories were emerged; hierarchical (N=7), spider (N=10) and mixed/both (N=5). Small number of participants explained sometimes they used both hierarchical and spider map types in the same CM while 7 participants did not explain the types of the maps that they have created. The preferences of the participants with respect to CM types were given in Table 4.6.

Table 4.6 *Preferences of Novice Participants on CM Types*

Types of Concept Maps	F	%
Hierarchical	7	24
Spider	10	34
Mixed/Both	5	17
None	7	24
Total	29	100

Furthermore, the written data showed that participants’ preferences on the kind of CMs in their future teaching life were divided into four; hierarchical (N=8), spider (N=9), both (N=5) and none (N=8). Only3 participants did not explain their future teaching life preferences and while small number of participants gave irrelevant information. The reasons for choosing hierarchical maps are respectively, its applicability, the easiness of visual representativeness, suitability to the content, enabling to check the missing information and continuity. On the other hand, some of the participants preferred to use spider maps, as they considered them more creative, effective and easily recognizable. According to them, it enables to provide all relations easily. Some of the participants indicated preference of the kind of CMs mostly depends on the content. Some examples for the visual representations of the mentioned CM types (hierarchical and spider/star) were given in figure 4.1. Some views from the participants were given below regarding their preferences about the types of CMs;

> 'I would prefer **hierarchical concept maps**. As students follow a path in these kinds of maps, the confusion possibility is lower.' (Novice5)
>
> Hiyerarşik kavram haritasını kullanmayı tercih ederim. Çünkü öğrenciler bu kavram haritasında belirli bir yol izlerler, kafalarının karışma olasılığı daha düşük.'
>
> 'I think I would use **hierarchical maps**. It is easier to see the general concept first and then descend to the particular.' (Novice6)
>
> 'Daha çok hiyerarşik kullanırım sanırım. Başta genel kavramı görüp, alta doğru ayrıntıya inmek daha kolay oluyor.'
>
> "I would think using **spider concept maps**, since it requires more creativity. (Novice7)
>
> 'Örümcek ağı kavram haritasını kullanmayı düşünürüm. Çünkü daha fazla yaratıcılık gerektiriyor diye düşünüyorum.'
>
> 'I would use **spider/star concept maps**. It helps us to comprehend the topic by showing the crosslinks.' (Novice8)
>
> 'Yıldız kavram haritası kullanırım. Aralardaki çapraz bağlantıları görmek kavramları daha iyi anlamamıza yardımcı olur.'

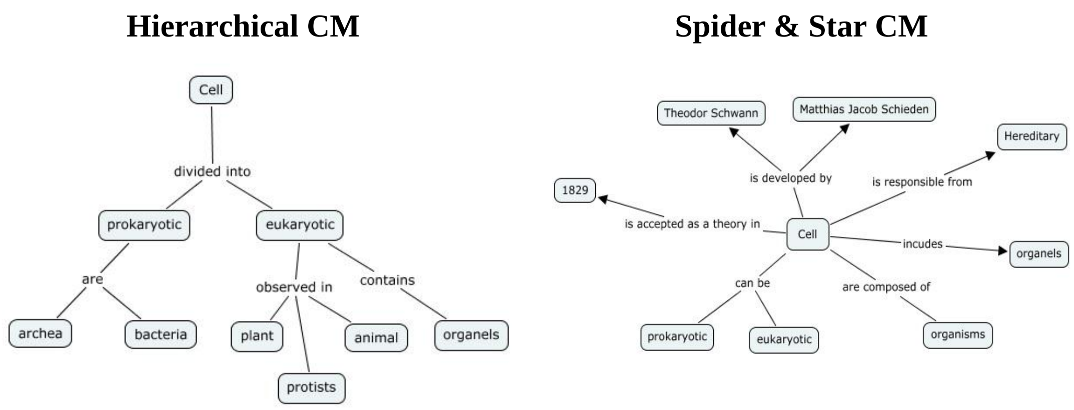


Figure 4.1 Examples of Hierarchical and Spider Maps

Opinions on future CM usage

For determining their future teaching life preferences regarding CMs, both written and verbal data were collected. Two questions were asked to explore their preferences about using CMs in their future teaching life and the kind of these maps. All the novice participants (N=29) expressed that they are willing to use CMs in their future teaching life. Their mostly indicated purposes for CM use in education were; providing an introduction to the subject, repeating the previously learned subject, summarizing the content effectively and assessing the knowledge easily. They also acknowledged the advantage of CMs as they help to determine the misconceptions easily, supporting spatial representations of the relations, providing a whole picture, helping to recall the previously learned information (meaningful learning). Parallel to this finding, verbal data also supported this view. All participants (N=14) agree that CMs were beneficial tools for education and they would use it in their teaching life frequently. Their mostly indicated reasons for using CMs were respectively; CMs enable looking at the whole picture easily (N=6), it has a memorable structure (N=3), enable summarizing the subject easily (N=2), allows teacher to check the misconceptions easily (N=4), has a potential for using as an assessment tool (N=1), and could reinforce the subject (N=2). Most of the participants were expressed that CMs could be used either for introducing or summarizing a subject. Some of the participants (N=2) indicated that it could be given as an assessment or homework for checking whether the students learned the subject completely. In addition some participants added that CM is a valuable tool for checking the misconceptions (N=3). According to them, CMs addresses visual memory and helping to prevent misconceptions. CMs had potential for assessing the students' knowledge and providing opportunity to check the missing points was also mentioned. One participant explained her view as;

> 'Yes, I am willing to use concept maps. Because, as I mentioned earlier concept map is the best summary of the topic represented. It put emphasis on the essential points and at the same time, it could be used to assess whether the student learned the topic or could transferred the information.' (Novice4)

> 'Evet, kullanmayı düşünüyorum. Çünkü başta da bahsettiğim gibi konunun en iyi biçimde sunulmuş bir ozetidir. Asıl bilinmesi gereken noktaları vurgular ve aynı zamanda öğrencinin konuyu öğrenip öğrenmediğini ya da bildiklerini aktarıp aktaramadığını ölçmekte de kullanılabilir.'

Benefits of CMs

The views of participants on the efficacy of the CMs were another issue explored in the study. All the participants expressed that they considered CMs promising; since they enabled conceptualizing the whole picture of the subject and helped to realize the unforeseen relationships. According to them, CMs also allow to highlight the important points, relationships and preventing misconceptions. Some of the participants mentioned the benefits of CMs while remarking the importance of CMs for assessment. They pointed out that it is not easy to develop a CM, without being aware of the topic's every aspect. Therefore, CMs have a potential for assessing whether the topic is learned or not. One participant explained her view on this issue is given below;

> 'Yes, I find CM beneficial, since it includes a summary of the topic. Even a person who does not have an idea about the topic could figure out what the topic is related, keywords and the relations among these keywords by looking at the concept map. In addition, if concept maps were given after the lesson it is a good method for assessing whether students grasped the information or not.' (Novice9)

‘Evet yararlı buluyorum. Çünkü konunun özetini içermektedir. Hiç konuyla ilgisi olmayan bir insan bile kavram haritasına bakarak konunun ne olduğunu, anahtar kelimeleri, bu kelimelerin birbirleriyle olan ilişkilerini gösterir. Bir de bir konudan sonra uygulanıyorsa öğrencilerin gerekli bilgileri alıp almadığını ve ne kadarını alıp almadıgını öğrenmek için iyi bir yöntemdir.’

Similarly, verbal data collected from experts showed a parallel result. According to them (N=5), CMs could be used in every stage in the lesson. For example, it is possible to use before starting the lesson, for introducing the new concept, reminding the previous subject or checking the misconceptions (N=3). Furthermore, it is also possible to use CMs in the process (N=3) for teaching the subject by using CMs. All experts agree that CMs are valuable tools and have potential to be used for reviewing and summarizing the subject. It enables the users to see the big picture and follow the information easily rather than the other methods. Specifically, one of the experts mentioned CMs could be used in every stage of the lesson; while starting the lesson as an advance organizer andin order to remind the previous lesson and show what have been done or introduce a new topic. And she continued with;

‘…It is possible to teach a subject by using concept maps or we could do many activities related with the lesson and teach many thinks. Concept maps simplify following the information. For example you can give the concept map at the beginning of the lesson, we have learned membrane last week and now we are going to learn organelles. In fact, we can use concept maps for showing the information, constructing the information in the students’ mind accurately and assuring them to construct true relationships in the right place. At the end of the lesson or unit, we can use concept maps as a summary. After all the things done, concept maps could be done together as an activity. It is also possible to use concept maps for assessment or evaluation purposes. It could be very effective but I have a big concern about being accustomed to the concept maps. It is not that easy to develop a concept map, it is necessary to have the students gained that familiarity very well.” (Expert1)

‘…Bir konuyu da çok rahat anlatabiliriz veya süreç içerisinde bir sürü etkinlik yapmış olabiliriz, bir sürü birşey anlatmış olabiliriz, onun orada takibini kolaylaştırmak yani dersin başında düşün verirsin sen bunu geçen hafta mesela hücrenin atıyorum kafadan membrane’ı anlatmışsınızdır, membrane’ı anlattık bakın şimdi organellerdeyiz gibi. Yani bilginin yerini göstermek, bilgiyi öğrencilerin kafasında doğru oluşturmak, doğru yerde doğru ilişkiler kurmasını sağlamak amaçlı yapabiliriz. Ondan sonra süreç içerisinde de anlattıkça adım adım o concept’i göstererek bakın şuradayız hala gibi şunları şunları öğreniyoruz gibi bir hatırlatmak, o bilgiyi doğru organize etmelerini sağlamak anlamında kullanılabilir. En son da summary amaçlı kullanabiliriz diye düşünüyorum. Herşey bittikten sonra öğrenciler ile birlikte yapılabilir bir etkinlik olarak. Assessment, sınav değerlendirme amaçlı olabilir. Yani çok çok faydalı olur ama tabi şey var, en büyük concern'im de öğrencinin bu kavram haritalarına alışkın olma meselesi. O kadar kolay birşey değil kavram haritası oluşturmak bence, o alışkanlığı iyi kazandırmak gerekiyor çocuklara.'

As it was understood from the expert's view, the applicability of CMs in different stages of the lesson was mentioned. She explained the reasons and the potential of CMs. However, it was observed that being accustomed to the CM development process could be an obstacle for the learners since it requires practice.

Main RQ: How do novices and experts establish their concept mapping processes?

RQ1: Do novices and experts use specific strategies during the concept map development process? /RQ2: How does the concept map development processes differ within novices and experts?

In order to gather information about the experts' and novices' behaviors during CM development process, written (inventory and interpretative essay), eye tracking and verbal (retrospective review) data collected. Since the experts have various experiences about CM, instead of administering inventory and interpretative essay, only verbal protocol and eye tracking data collected from them. The data analyzed with a holistic approach, participants' starting strategy, and general strategies, whether they have a strategy while filling information on CM and specific branch patterns. The results showed that, there were differences between these two groups of participants in terms of starting strategy, strategy followed through the process and branching pattern.

4.2 Novices' and Experts' CM Development Strategy

General Strategy: Deductive or Inductive

The written data analyzed to explore whether novices and experts followed a specific strategy during CM development. The written data; inventory and interpretative essay results showed that novices followed *a deductive strategy* during the CM development process. According to inventory results, it was seen that majority of the novice participants (N=17) explained that they preferred to use a deductive strategy during CM development process. According to them, CM development is process including various small steps like; planning, deciding the type of the map, setting a goal, grouping the concepts and relations in terms of their priority, determining the branches and placing the main concept. Some of the participants (N=12) did not declare a specific strategy but they expressed the importance of summarizing the information, grouping them in a logical way and using short and meaningful sentences during the CM development process. Interpretative essay results showed a parallel view with the previous findings coming from inventory responses. The results confirmed that most of the novice participants (N=25) tended to follow a pattern from general to specific which is similar to the preliminary findings. One of the novice participants explained her strategy as follows;

> 'I had given an example after I divided Cell structurally into two. I consider keeping it for a while since it seems like it could prevent my progression. I tried to **continue from general to specific**. Sometimes, I used some concepts like organelle, and cell membrane twice, because the main headings were different. If I used these concepts once, it would be logically incorrect.'(Novice10)

> 'Hücreyi yapısal olarak ikiye ayırdıktan sonra örnek vermiştim. Onu bekletme gereği duydum sanki ilerlememi engelleyecekmiş gibiydi.Genelden özele gitmeye çalıştım. Organel, hücre zarı gibi kavramları iki kere kullandım. Çünkü ana başlıklar farklıydı. Bir kere kullansaydım mantık hatası olurdu.'

Some participants' strategies could be considered under the deductive thinking respectively; determining the basic concepts and relations, positioning the basic concepts (N=4), organizing and positioning the concept and relations (N=9). In addition, they mentioned the importance of organization of the arrows and directions. Only one participant did not mention his/her strategy. 4 participants did not declare their strategies during CM development process. See Table 4.7 for the summary of the written data.

Table 4. 7 *Summary of the Novice Participants' Written Data Results*

	Written data					
	CM Inventory N=29			Interpretative Essay N=29		
	Inductive	Deductive	No strategy	Inductive	Deductive	No strategy
Novices	-	17	12	-	25	4

The researcher also analyzed all participants' eye movement recordings to investigate whether specific strategies used in the CM development process. In addition to eye movement recordings, verbal protocols were administered to explore the traces of cognitive process and triangulate the eye movement recordings. The results gathered from eye movement recordings and verbal protocols showed a parallel view to the written data results that there was an observable pattern among both expert and novice participants in CM development process. They generally followed a deductive manner and tended to construct their maps from general to specific. One of the novice participants explained her/his strategy during the CM development as;

> 'I usually look at the subject could be splited up how many basic branches. Then I continue with the sub concepts. It is like painting a tree, first placing the tree trunk, then the branches and drawing the leaves. At last, it proceeds by forming the forest by relating with the other subjects.' (Novice11)
>
> 'Genelde konu kaç ana dala ayrılmış ona bakıyorum. Sonra alt birimlerine geçiyorum. Resim yaparken ağaç çizmek gibi önce, ana gövdeyi yerleştirip sonra dalları, yaprakları çizmek ve en son olarak da diğer konularla ilişkilendirip ormanı oluşturmak.'

According to eye movement recordings, it was seen that all novice participants (N=29) followed a deductive strategy likewise all expert participants (N=5) followed. Only one expert participant expressed that she followed an inductive strategy during CM development. She explained her position about embracing an inductive strategy during the CM development process as;

> 'Actually the strategy depends on the subject, if the subject is a complex one, hard to be grasped maybe it would be more reasonable to start with a simple thing and come to the general lines. For example, you can start with water vapor and spread the matter's every line step by step.' (Expert2)
>
> 'Yani aslında, bu (strateji) konuya göre değişir, hani eğer böyle çok zor bir konu, belki kavratılması zor bir konu olursa belki en basitinden gidip genel hatlara ulaşmaya çalışmak daha mantıklı olabilir. Mesela su buharından gidip yavaş yavaş maddenin her tarafına dağılabilirsin.'

All participants started with placing the main concept at the first step and afterwards they construct the sub concepts and links while keeping in mind the relations between the main concepts. This approach enables the participants to go into details. On the other hand, the verbal protocol data showed that most of the experts (N=5) indicated they haven't got a specific strategy during CM development process. They (N=5) also added that they did not plan something before starting the map, no starting strategy beforehand the CM development. However, it was seen that they tend to use a deductive strategy and give attention to establish from general to specific, based on both eye movement recordings and their subsequent statements during the verbal protocols. Only one participant explained that she used to follow an inductive strategy during the CM development, from simple to general idea. See table 4.8.

Table 4. 8 *Common Strategies among Novices and Experts Based on Eye Movement and Verbal Data*

	Eye Movement Data				Verbal Data			
	Deductive		Inductive		Deductive		Inductive	
	f	%	f	%	f	%	f	%
Novices	29	100	-	-	14	100	-	-
Experts	5	75	1	25	4	80	1	20

In order to determine whether participants had a deliberate strategy in their mind before starting CM, their previous thought about the process were explored. In order to have a thorough knowledge of participants' cognitive process, and determining whether they have a deliberate strategy in their mind before starting CM, their starting strategies and thoughts were asked with the help of interpretative essay questions. The interpretative essay data results showed that only 5 participants explained that they envisaged a CM in their mind before starting. This might be related with being not sure about a definite CM development strategy in advance. The other participants did not mention a specific starting strategy. They mostly indicated that they haven't got a strategy in their mind; some of them explained that they have a tendency to write the information which comes to mind first. Some of the issues mentioned before starting the CM; like finding appropriate linking words (N=15) and concepts (N=3), the common characteristics of the subject (N=3), self-efficacy about the number of concepts and CM development (N=2) and the type of the CM (N=1).

In addition to their common strategies during CM development and starting strategies before starting CM, the underlying reasons were asked to the participants. The findings indicated that there were many reasons for preferring a deductive strategy instead of others; it enables structuring relations more easily and smoothly (N=4), it has a potential for simplifying the comprehensibility of the CM (N=4), it enables tracing the missing points easily (N=3), nature of the subject which is dependent to deductive strategy (N=3), the similarity of structured image of a subject in mind and screen (N=2) and prior experiences on CM with deductive strategy (N=1). Moreover, some of the participants declared that although they used to adopt deductive strategy, arrangement problems occurred during the process which forced some participants to use inductive strategies. One of the novice participants explained out this process like;

> 'I followed a path from the main concept to sub concept. I can understand better like this, since I understand better like this I reflect like this.' (Novice6)
>
> 'Üst kavramdan alt kavrama doğru ilerledim. Böyle daha rahat anlıyorum, bu şekilde anladığım için de böyle yansıtıyorum.'

Furthermore, the order in writing link or concept word was another explored issue to have information on the CM development strategy. For this reason, the participants were asked how they fill the map by using verbal protocols. In terms of the order of writing into linking word or concept, many participants explained that they did not have a specific strategy. Although they did not have a specific strategy, both novices (N=25) and experts (N=5) tended to write into linking word and then write into concept. Some of the novices (N=2) and experts (N=1) indicated that they wrote first concept and then linking word (N=2). In addition, some participant explained that they did not have a specific strategy, they could either use both, but it mostly depends on the information order flashed into their mind.

The verbal data was parallel with the previous results, most of the novices (N=10) tend to write into linking word and then write into concept, while some of the participants (N=4) preferred to write into concept rather than writing into linking word. There is a similar situation observed among experts, most of the experts (N=4) explained they first wrote into linking word while one participant expressed writing into concept was common for her. See table 4.9 for the summary of the strategies in terms of filling the CM in a specific order.

Table 4.9 *Strategies among Novice and Expert Participants Derived from Eye Movement and Verbal Data*

	Deductive Strategy	Eye Movement Data (N_{Novice}= 29, $N_{Experts}$= 6)			Verbal Data (N_{novice}=12, $N_{Experts}$=5)		
		Link-Concept	Concept-link	Both	Link-concept	Concept-link	Both
Novices	29	25	2	2	10	4	-
Experts	6	5	1	-	4	1	-

Hierarchical or Spider Type Maps

In order to understand the CM development process and the potential differences between the expert and novice participants, participants CMs were analyzed with the aid of eye movement recordings. The analysis of the eye movement recordings showed that ($N_{Novices}$=21, $N_{Experts}$=6) most of the participants preferred to use hierarchical maps instead of spider maps ($N_{Novices}$=2). Moreover, it was found that some of the novice participants (N=5) used both hierarchical and spider map features during their CM development. None of the experts used spider or mixed CM type on their CM development process.

The verbal data also confirmed the eye movement results, both novice (N=6) and expert participants (N=5) chose to develop hierarchical maps. Some of the novice participants used spider (N=3) and mixed maps (N=2) while none of the expert participants preferred to use spider or mixed maps. Some of the novice participants (N=3) did not declare their CM type. When the eye movement and verbal data compared to written data, it was seen that, some of the participants preferred to develop their CM hierarchically although they (N=9) declared their preferences regarding CM was spider. This might be related with the subject matter nature and its suitability to the hierarchical type maps. See table 4.10 for comparisons of different types of data based on CM type preferences.

Table 4.10 *Comparisons of Eye Movement, Verbal and Written data based on CM Type Preferences*

	Eye Movement Data (N_{novice}=29, $N_{Experts}$=6)		Verbal Data (N_{novice}=12, $N_{Experts}$=5)		Written Data $N_{Novices}$=29	
	Novices	Experts	Novices	Experts	Novices	Experts
Hierarchical	21	6	6	5	6	-
Spider	2	-	3	-	9	-
Both/Mixed	5	-	2	-	6	-
None	-	-	3	-	8	-

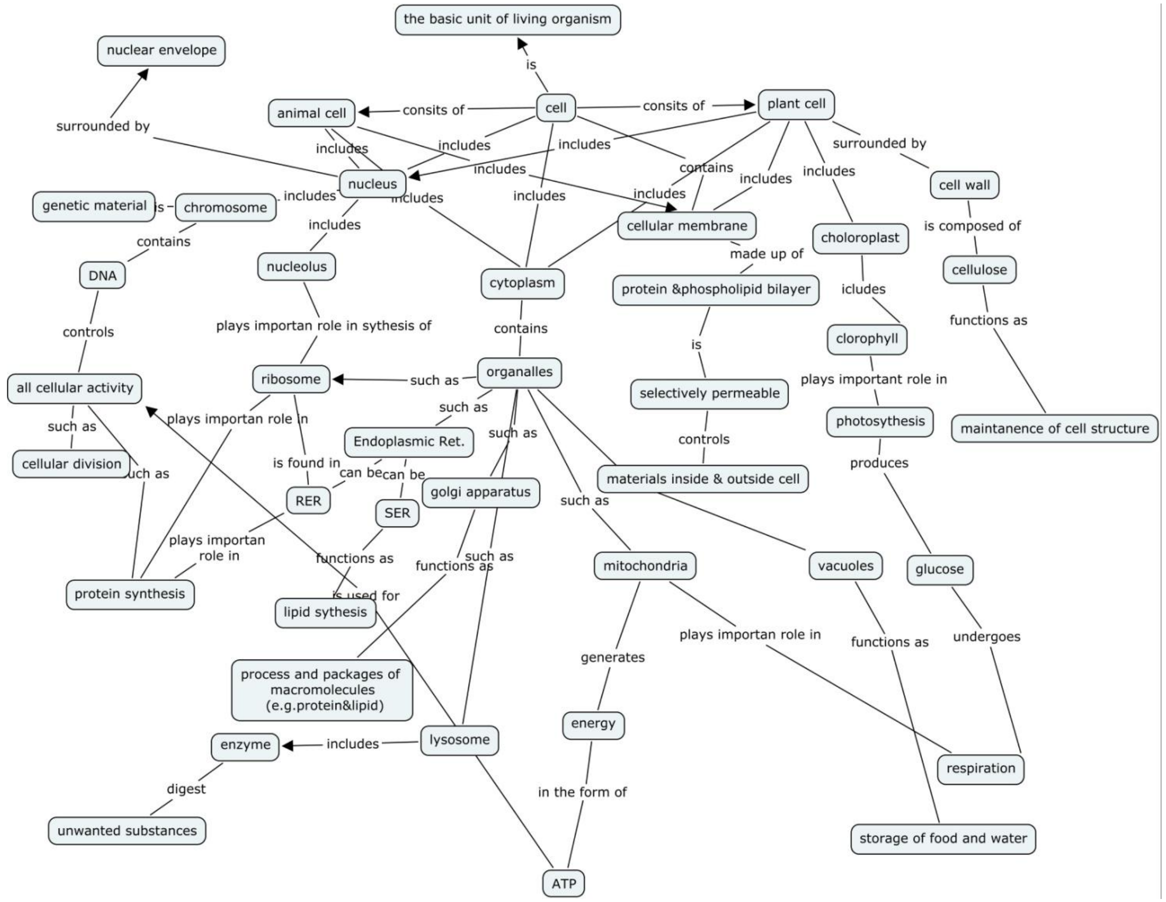


Figure 4. 2 An Example of an Expert Concept Map

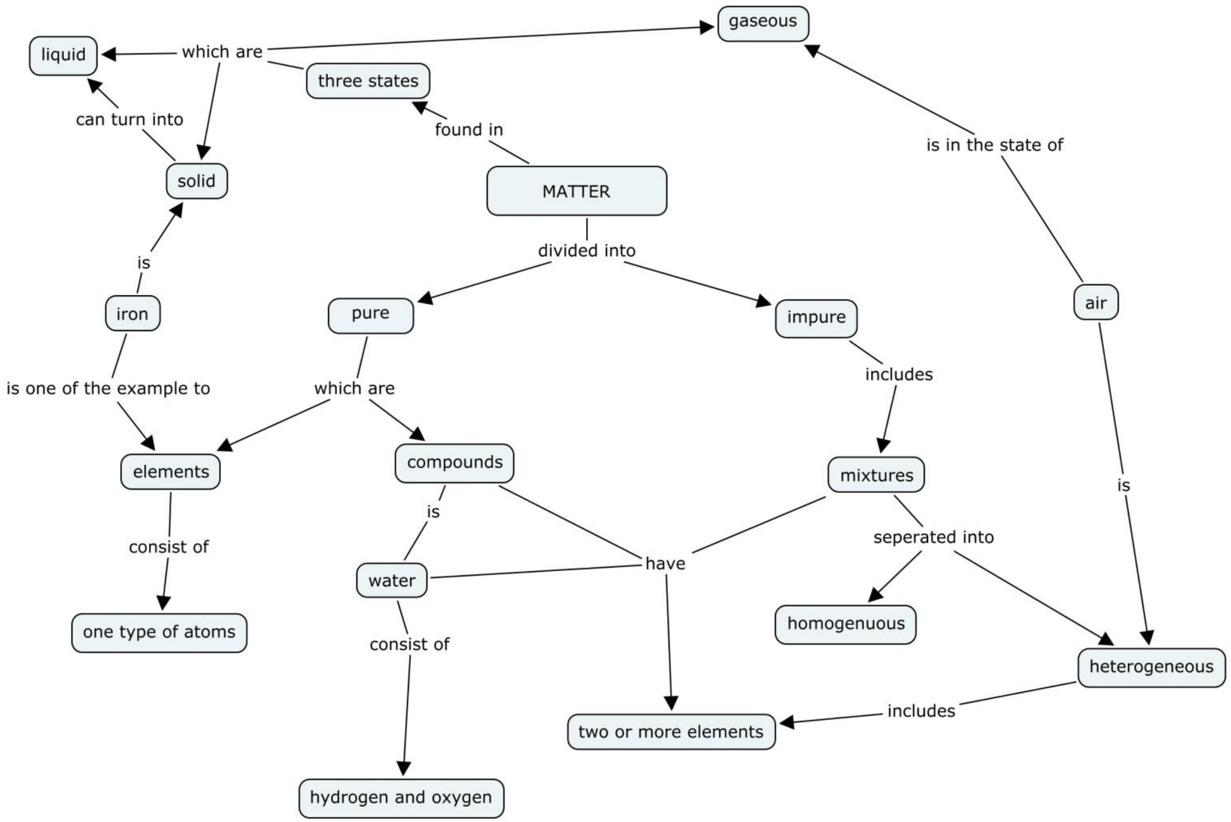


Figure 4. 3 An Example of a Novice Concept Map

Branch Construction Pattern

In addition to the general CM strategy, participants other potential strategies during this process were explored by analyzing their eye movement recordings and verbal protocols to see whether experts and novices followed a specific pattern during the branch construction. They have asked to give information about their branch construction patterns. The results based on eye movement recordings showed that most of the novice participants (N=24) followed a synchronized strategy while constructing branches, filling information while paying attention to keep the similar information in the same level on CM which could be named as a *mirror image* strategy. They had an order while filling a branch, and if they started to give example to one concept belongs to one branch they tend to give examples to the other equivalent branches concurrently. See Figure 4.4.

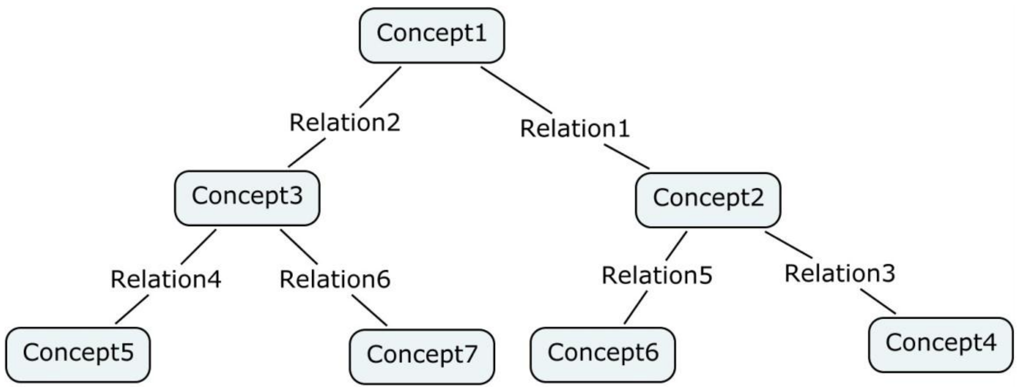


Figure 4.4 A Screenshot for Syncronized Branch Construction Pattern

Some participants (N=5) tended to complete a branch with the information belongs to that branch and then continued with the other branch. On the other hand, experts showed a totally different pattern, completing a whole branch and continue with the other branch. Only one expert followed a synchronized strategy.The verbal data also proved that most of the expert participants (N=4) followed a strategy as completing a branch and then continue with other branch instead of writing equal information under every branch (N=1). See Figure 4.5.

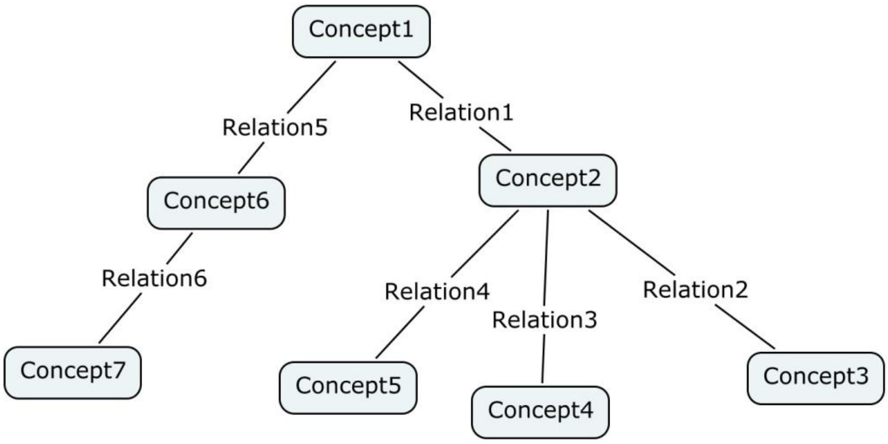


Figure 4.5 A Screenshot from Completing a Branch Pattern

The verbal protocol data results confirmed the previous findings from eye tracking data. All novice participants (N=14) expressed that they followed a synchronized manner while placing the linking words and concepts. They explained that they tended to use a synchronize pattern while writing one concept belonging to a branch and then kept going to the other branch's concepts which is equally complement to the other. Only one participant did not explain her strategy during the verbal protocol. The emerged pattern among experts was different than the novice participants as it was observed in eye behavior analysis. Most of the experts (N=4) followed a reverse strategy, as completing a branch instead of writing equal information under every branch. Only one participant indicated that she used to follow a synchronized pattern. See Table 4.11 for the summary of the results.

Table 4.11 *Summary Table for Strategies Emerged from Eye Movement, Verbal and Written Data*

	Eye Movement Data $N_{Novices}$= 29 /$N_{Experts}$=6			Verbal Data $N_{Novices}$=12/ $N_{Experts}$=5			Written Data $N_{Novices}$=29	
Novices	Deductive strategy	Branch construction		Deductive strategy	Branch construction		Deductive strategy	NA
		Mirror Image	Completing a branch		Mirror Image	Completing a branch		
Novices	29	24	5	14	14	-	17	12
Experts	6	1	5	4	1	4	-	-

Moreover, the results coming from verbal data showed that although many novice participants declared that they did not have a specific strategy before starting the CM, they followed a deductive manner during CM development process. Some participants expressed they had a concern about placing the concept in an order, and constantly planning the next step consciously or unconsciously. In addition, even they had no specific plan for their CMs, they tended to construct the concepts and relations in a deductive way and design the visual representation and follow that order. Some of the participants explained that they did not have a detailed plan in their mind before developing the CM but the main groups were organized in their mind unconsciously. Two participants' views were given below;

> 'In fact, I already have a concept map in my mind, as I said before visual is easier because it is like a picture in my mind. Besides, we used to learn like this, matter, elements, compounds with arrows on board in school. For that reason, it is already apparent in my mind, the format of the concept map.' (Novice12)

> 'Yani kafamda zaten hazır gibiydi, biraz önce dediğim gibi visual daha kolay çünkü kafamda zaten tablo halinde. Bir de biz hep öğrenirken öyle öğrendik galiba bunu, madde, elementler, bileşikler oklarla hep tahtada. Zaten benim ne yapacağım belliydi kafamda concept map formatı.'

> 'While developing the concept map, first I divided the map in terms of the phases, and then classified in terms of being pure or no pure that occurred in my mind. However, I did not have an idea about how I would divide concept map in my mind. However, I have defined the main concepts in my mind.' (Novice5)

‘Burada oluştururken fazlarına göre, ondan sonra saf olup olmayışına göre kafamda hani onlar oluştu ama şöyle ayırayım böyle ayırayım diye hani bir map oluşturmadım kafamda. Ama hani ana maddeleri belirledim kafamda.’

As it was understood from their comments, before starting their map they had a general image about the CM was drawen in their mind and they tended to follow that image during the process. In addition, determining the basic points in mind instead of imaging a tentative map in mind was another way before starting the map. See figure 4.6 for a visualization of the deductive strategy.

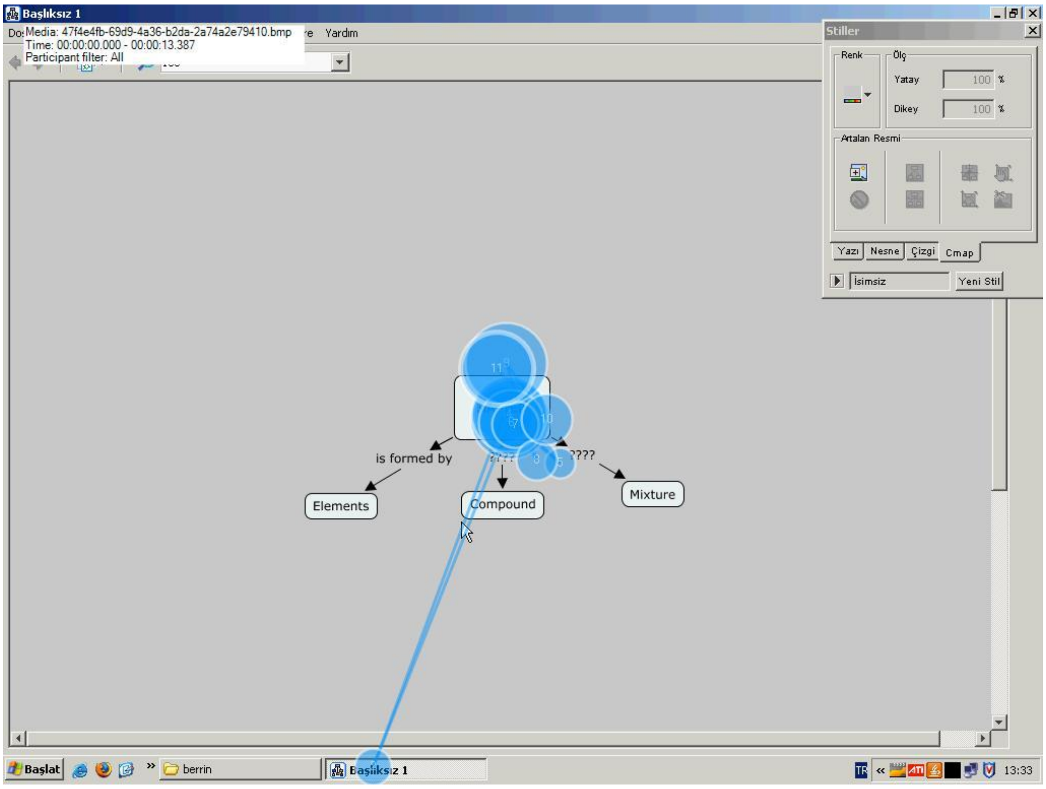


Figure 4.6 A Screenshot from a Novice Participant’s Gazeplot

The verbal protocol data results showed that, experts did not declare an predetermined plan for their CM development in advance, but eye movement analysisand their subsequent statements about their steps during their CM development process showed that their mapping process was more structured’ planned and smoother than the novices. Although they did not mention a specific strategy on CM development, the clues were gathered from the verbal protocol about their CM development and their embraced strategies. Moreover, their eye behavior pattern also proved their embraced strategies during CM development process. One of the experts explained her strategy like;

> 'While developing a concept map, you need to determine a strategy and remain the borders of that strategy. Otherwise, you can give some concepts very detailed than the others. Actually I think every concept at the same time and tried to keep them in an equivalent level. That is, while giving a function for one concept, I thought that need to give the other concept's function, too. I determined a specific strategy in my mind.' (Expert1)
>
> 'Strateji belirlemek gerekiyor ve onunla sınırlı kalmak gerekiyor. Aksi takdirde birinin çok özelliğini verip, hepsini aynı yapıda yani ben öyle düşündüm yani en azından birinin bir şeyini verdim mi hepsini aynı düzeye getirmek istedim. Yani birinin fonksiyonunu verirken diğerini de vermeliyim diye düşündüm. Yani belirli bir strateji belirledim kafamda.'

The observations of the researcher showed that experts had an internalized mapping strategy that they did not declared precisely. However, verbal data collected through them showed a parallel view to the observations as they had a structured strategy and they were aware of the process in detail before starting the map. See Figure 4.7 for a visual representation of an expert participant's deductive strategy during CM development.

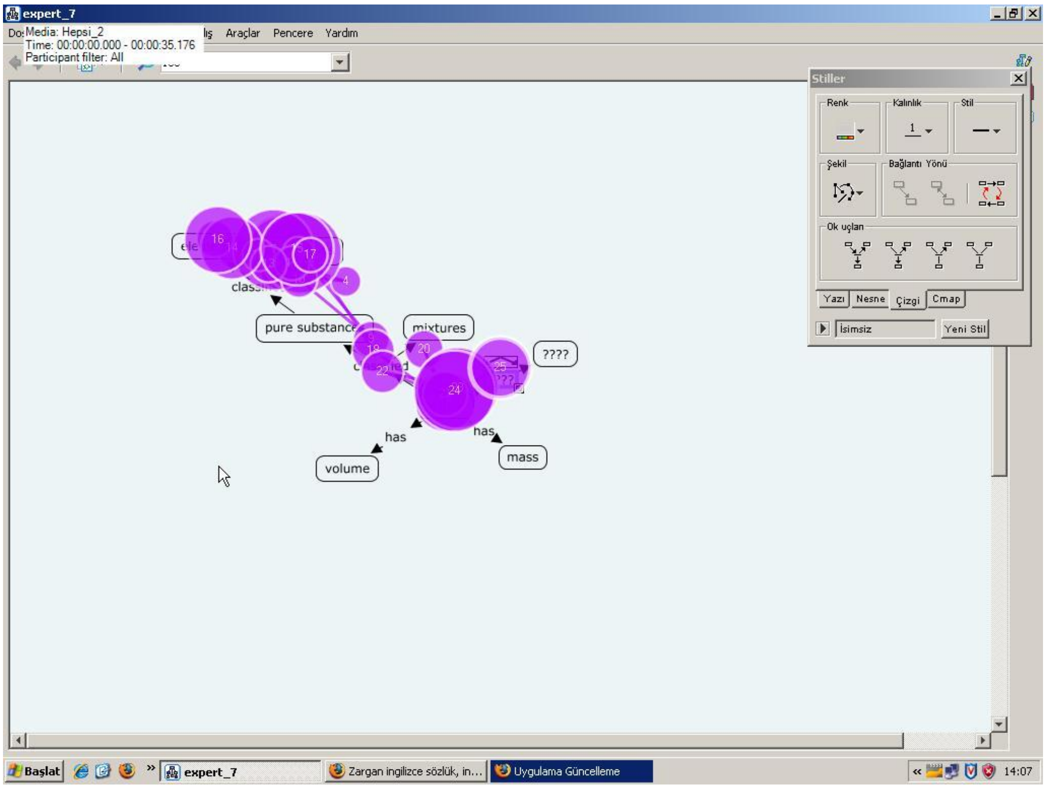


Figure 4.7 A Screenshot from an Expert Participant's Gazeplot

Critical Points during the Concept Map Development Process

In order to explore whether there are any critical points and obstacles participants experienced during CM development, novices' views were asked by using CM inventory and interpretative essay. The results showed that the most critical point for novice participants was 'forming accurate and exact number of relations' (N=21). They also paid attention to follow a deductive strategy during CM development (N=7). Other important points in this process were expressed respectively; covering the related concepts (N=6), including basic points (N=6), providing comprehensibility (N=3), preventing long sentences (N=2), being proficient on the subject (N=2), giving emphasis to aesthetic issues (N=2) and constructing cross-links (N=1).

The stages during the CM development and participants' view on these steps in terms of their easiness and the reasons were explored by using interpretative essay instrument. According to the results, the easiest step in CM development process was declared as *naming the concepts* (N=14) and *constructing branches* (N=11). The participants explained the underlying reasons for the easiness of these steps as their prior knowledge and experiences, and the existence of concepts in their mind already which makes this step easier than the other steps. Specifically, some of the participants (N=7) explained the naming process in detail and they indicated that they follow a deductive strategy while naming the concepts. They also mentioned that constructing concept step facilitated the branching step.

On the other hand, *constructing relations* was considered relatively harder than the other steps by the participants (N=13). They pointed out the importance of finding an appropriate linking word which could link two concepts clearly and explicitly. The importance of preventing the misconceptions by using appropriate linking words was also pointed out. A small number of participants (N=2) indicated that naming the general concepts and placing them in CM was easier than writing the details. In addition, unlike other participants' one of the participants explained that naming concepts was the hardest step for her;

> 'Naming was the hardest part for me. I mean the key point for an accurate result depending on beginning correctly. After I have named the concepts, I constructed branches and make relations among the concepts more rapidly.' (Novice9)
>
> 'İsimlendirme en zor kısmıydı. Yani başı doğru kurmak doğru sonucu getirmektir bence. İsimlendirmeyi yaptıktan sonra dallandırmayı ve ilişki kurmayı daha çabuk yaptım.'

Additionally, eye behavior analysis results showed that majority of the participants had either deleted some information or made revisions on concepts or relations during CM development process. This result supported with the written data (interpretative essay results) as most of the participants (N=23) expressed that they had done revisions and sometimes deleted some information on their maps. Six participants did not explain their ideas on this issue. The main reasons for deleting or changing concepts and relations respectively; finding a proper word or realizing the inappropriateness of some words (N=11), having concerns about keeping the CM simple (N=4), finding a better place for either the concept or relation word, realizing the necessity of adding some concepts or relations, ascertaining some redundant words (N=2), the possibility of preventing improvement in CM (N=2) and having tool related problems (N=1).

Summary of the Results (Section 4.2)

The analysis of the results revealed the following major findings;

- General Strategy: As a general strategy while developing a CM; novice and expert participants showed a similar pattern. A deductive strategy is observed between participants; which includes starting with a general concept at the first step and afterwards continue with constructing sub concepts and links while keeping in mind the relations between the main concept. Underlying reasons for choosing deductive strategy were found as; structuring the relations more easily and smoothly, prior experiences with deductive strategy, the similarity of structured image on a subject in mind and suitability of the subject to this strategy.
- Deliberate Strategy: Most of the novices declared that they did not have a deliberate strategy or plan in their mind before starting the CM. Instead of embracing a specific strategy, they expressed that they tended to write the information which comes to their mind first. Only a few participants envisaged a CM in their mind before starting the map. However, the verbal protocol data and eye movement recordings showed that they tended to follow a strategy (deductive) during CM development. This might be related with the knowledge awareness of novices about their CM development process, as they might not be aware of their embraced strategies.
- Other patterns revealed;

- Filling the information in an order: Both experts and novices followed a specific pattern while filling the information on CM. Writing into linking word and then the concept is common between the participants, which might be related with the information processing order in mind, language proficiency (having problems while finding a proper English word) and their learned behavior.
- Hierarchical or spider map preference: A majority of the experts and novices preferred to use 'hierarchical' CMs instead of 'spider' CMs. This might be associated with the embraced strategy 'deductive thinking', and the suitability of the nature of the subject to hierarchical mapping.
- Branch construction: In terms of constructing branch during the CM development process, experts and novices followed different patterns. Novices had a tendency to follow a synchronized pattern; if they started to give an example or mentioned about a feature which belongs to one branch, they tended to give similar information to the equivalent branch concurrently. This was called by the researcher as "mirror image". There was a synchronized act while writing information under the different branches. On the other hand, experts showed a reverse pattern; they completed a branch instead of writing equal information under every equal branch.

- Other critical issues during CM development process, that they gave emphasis mentioned by the novices;
    - Forming an accurate and exact number of relations
    - Using a deductive strategy
    - Covering the necessary amount of related concepts and basic points

- The easiest steps during CM development were respectively; naming the concepts, branching and constructing relations among concepts. The easiest step was naming the concepts as declared by the novice participants. They expressed that they had already known the concepts. This might also be related with their prior knowledge on the concepts which was mostly affected by rote learning. They might have learned the concept names by rote learning and could remember the names without thinking the definition or function but associating them with other concepts in a meaningful way requires more than memorizing the information. Furthermore, constructing a relation among two concepts requires information processing, grasping a new knowledge while connecting with the prior one. This might also affect the preferences of the participants'.

- Revisions and its reasons: Novices explained that their revisions during CM development process was related with finding a better represented word for relations and realizing the inappropriateness of some information later. On the other hand, experts made less revisions and the underlying reason for these revisions was mostly tool related.

- Challenges and obstacles:
  - Both novices and experts experienced problems related with the tool adaptation. Although they expressed that the tool is easy to use, it was understood that participants need a longer adaptation period.
  - Most of the novices experienced organization related problems during CM development. Experts did not indicate an organization related problems instead their common problems were related with tool adaptation.
  - English proficiency and the limited vocabulary of the novices was another problem, especially finding a proper word for relations became a critical issue for them. Experts did not experience any problem related with this issue.
- Subject matter effect: The written data proved that subject selection was an important factor affecting the CM development process directly. Familiarity of the subject eased and shortened the completion period.

4.3 Eye Movement Analysis Results

RQ 2.1: Are there differences between novice and expert participants in terms of their eye behavior? (e.g. FC, VD and FD)

In this study, the main expectation was to have an understanding on novice and expert participants' CM development processes. In this respect, participants' eye behavior was chosen as a basis for the analysis. In order to determine whether there was a pattern among novices and experts in terms of their eye behavior, some measures were used like FD, FC and VD. Fixation is defined as an intentional rapid eye movement, and fixation count is the total number of fixations on a predetermined area. Total visit duration is the total time spent during the CM development process. This period is different than the total recording time, because this period is just calculating the eye movement time instead of including the other time spent (no eye movement caught, looking at keyboard and any other area than the screen).

While analyzing the FC of the participants, the researcher analyzed the video for each participant frame by frame. There was no time limitation for the task and this caused a varied time periods. In order to prevent large number of fixation number due to the long period of time during the task and had a standard between participants, each FC number was divided into the period of time spent to obtain a standardized number for each participant.

In order to gather information about the cognitive process of the participants, and investigate the potential differences between novice and expert participants on CM development process, the FC number were analyzed. The results showed that novices had more FC on their CMs than the experts for both subject matters which could be interpreted as they had an extensive cognitive process during the CM development process. In addition, FC number of the novice participants who developed CM in Matter subject was higher (M=59.43) than the Cell subject matter (M=41.33). Same situation was observed among expert participants, their FC numbers was higher in Matter subject (M=20.08) than the Cell subject (*M*=17.24). See Figure 4.8.

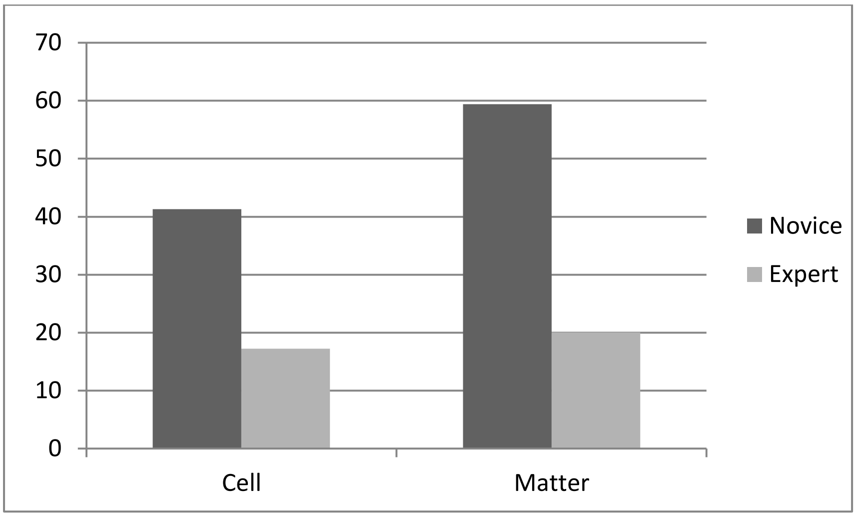


Figure 4.8 Average Fixation Count Numbers for Novices and Experts According to Different Subject Matters

In addition to the FC number metric, participants' average FD periods during CM development process were compared to see whether there was a difference between novice and expert participants for different subject matters. The results showed that novice participants' average FD period was lesser (*M*=5.63 sec.) than the experts participants' (*M*=11.16 sec.) for Cell subject matter. On the other hand, for the Matter subject, the FD values for experts and novices were closer, novice participants spent 9.77 sec. while experts 10.85 sec. See Figure 4.9.

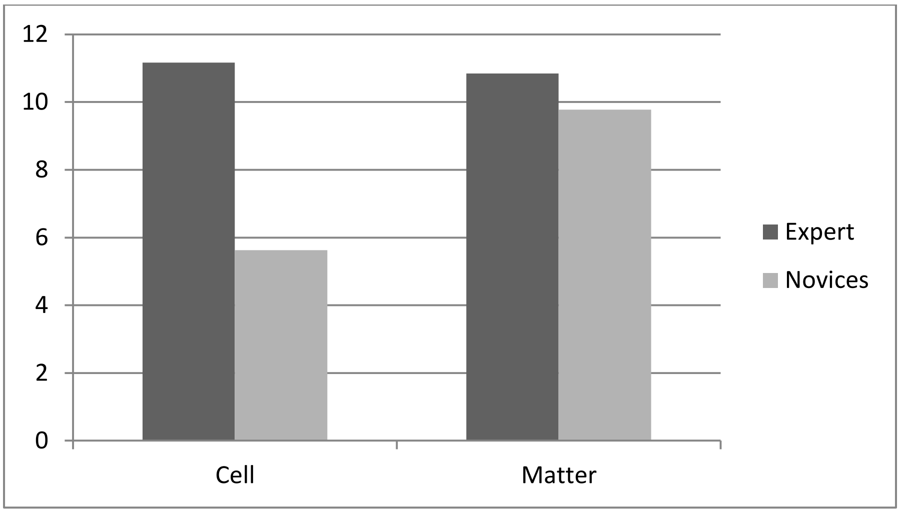


Figure 4.9 Average Fixation Duration Spent by Novices and Experts for different Subjects Matters

Furthermore, both novices' and experts' total VD were examined to explore the possible differences among participants for different subject matters. The results showed novice and expert participants' average VD periods were very close to each other in Cell subject ($M_{Novices}$=19.11, SD=7.82; $M_{experts}$=22.02, *SD*=6.98) than the Matter subject ($M_{Novices}$=22.27, *SD*= 10.21; $M_{Experts}$=43.77, SD=17.0). Novice participants spent less time than the experts in both subjects. The analysis showed that in terms of their eye behavior different patterns observed between novices and experts. The complex nature of CM development process caused participants spending considerably long period of time. The increase in time spent on task affect directly the FC number. To sum up, novice participants had less FD in both subjects than the expert participants. Parallel to this result, novices' total visit durations were also lesser than the experts in both subjects. Moreover, their FC numbers were higher in novices than the experts in both Cell and Matter subjects. See table 4.12 for the summary of the eye behavior results. See figure 4.10.

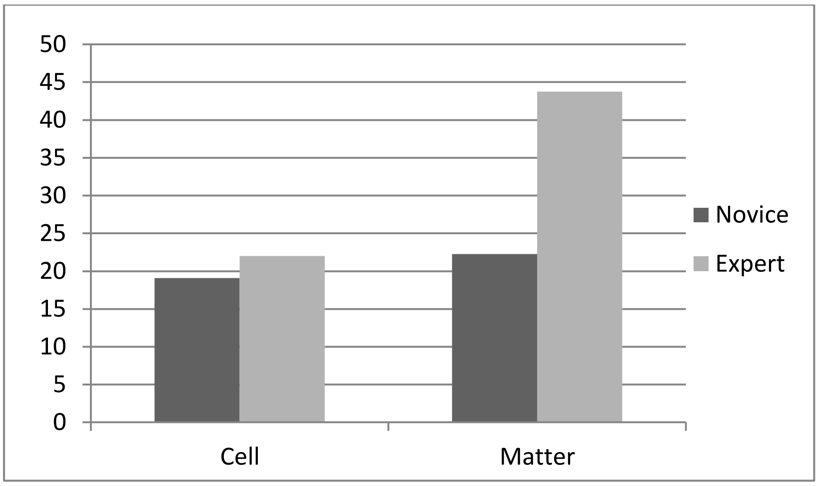


Figure 4.10 Total Visit Duration for Novices and Experts According to the Different Subject Matters (*min)

Table 4.12 *Summary of the Fixation Duration, Fixation Count Number and Total Visit Duration Numbers for Novices and Experts According to "Cell" and "Matter" Subjects*

Expertise	Subject	N	FD		FC		VD	
			M	*SD*	*M*	*SD*	*M*	*SD*
Novice	Cell	12	5,63	1,85	41,33	18,79	19,11*	7,82
	Matter	17	9,77	3,13	59,43	48,83	22,27*	10,21
Expert	Cell	3	11,16	0,70	17,24	4,03	22,02*	6,98
	Matter	3	10,85	3,68	20,08	5,45	43,77*	17,00

*min

In addition to FC, FD, and VD values while considering the subject matter difference, the difference in some selected acts (preteremined acts while analyzing the entire process) were explored. The researcher explored the differences between novices and experts in FD on these actions according to different subject matters. Three basic acts were chosen which could be representative for the cognitive process directly, *cross-link*, *controlling and checking* and *reasoning*. The underlying reason for choosing these acts was their potential to give information on cognitive process. Since constructing cross-links requires analysis of the two different branches and linking them by using an accurate word, which could be taken into account of cognitive process. In addition, while controlling the map, the participants had a cognitive process which includes both checking the accuracy of the concepts and links while thinking for a accuaret concept word. Reasoning also comprised a cognitive process that constructing new information on a CM. For that reason, these three acts were chosen as a basis for exploring the cognitive process during the analysis.

According to the results for Cell subject, there were differences in FD values between novice and expert participants for cross-link, controlling and checking and reasoning acts. Novices' FD values were lesser than the experts in Cell subject. Specifically, in cross-link act for the Cell subject FD was considerably high in expert participants (*M*= .97, *SD*= .17) than the novice participants (*M*=.28, *SD*=.25). This was an expected result for this study, since constructing cross-links requires an extended information processing (linking two different branches by using a linking word) and necessitates associating new information with the previous one. Since experts had an extended knowledge, this enabled them to construct more cross-links during CM development process than the novices. In addition, mean scores for controlling and checking action of the expert participants (*M*=.48, *SD*=.11) was fairly higher than the novice participants (*M*=.16, *SD*=.12). See Table 4.13.

Table 4.13 *Novice and Expert Participants' Fixation Durations for Specific Acts (Cell)*

	N		*M*	*SD*	Min	Max
Novices	12	Controlling & Checking	.16	.12	0	.28
		Crosslink	.28	.25	0	.73
		Reasoning	.35	.11	.17	.49
Experts	3	Controlling & Checking	.48	.11	.80	1.13
		Cross-link	.97	.17	.80	1.13
		Reasoning	.52	.03	.50	.55

According to the results for Matter subject, there were differences in FD values among novice and expert participants for cross-link, controlling and checking and reasoning acts. Novices' FD values were lesser than the experts in Matter subject. Specifically in cross-link act for the Matter subject FD was considerably higher in expert participants (*M*=.67, *SD*=.63) than the novice participants (*M*=.47, *SD*=.38). Experts' FD periods for reasoning act was higher (*M*=.50, *SD*=.07) than the novices (*M*=.45, *SD*=.13). In addition, experts' FDs for controlling and checking act (*M*=.37, *SD*=.02) was higher than the novice participants (*M*=.33, *SD*=.15). See table 4.14.

Table 4.14 *Novice and Expert participants' Fixation Durations for Specific Acts (Matter)*

	N		*M*	*SD*	Min	Max
Novice	17	Controlling & Checking	.33	.15	0	.61
		Cross-link	.47	.38	0	1.07
		Reasoning	.45	.13	0	.62
Expert	3	Controlling &Checking	.37	.02	.36	.39
		Cross-link	.67	.63	0	1.25
		Reasoning	.50	.07	.50	.57

Summary of the Results (Section 4.3)

- In order to determine the eye behavior pattern among novices and experts, some eye movement metrics were used, FC, FD and VD. The analysis showed that novice participants had less FD in both subjects than the expert participants. Parallel to this result, novices' VD periods were also lesser than the experts in both subjects. Moreover, novices' FC numbers were higher than experts in both Cell and Matter subjects.
- Furthermore, three main acts were selected to observe whether there was a difference among expert and novice participants for these acts while considering the early mentioned metrics. According to the results, there were differences between expert and novice participants for FD metric. Especially in cross-link act, the FD was considerably higher in expert participants in both subjects than the novice participants. Although the FD values for controlling and checking act was fairly higher in Cell subject for experts than novices, in Matter subject the values were relatively close each to other but slightly higher than the Cell subject FD values. For these specific acts, it was observed that some of the participants did not have any FC number while some participants had considerably high FC numbers. As a result the

difference between their mean scores and SD values are meaningless, and these FC and VD values were not taken into consideration during the analysis and not given in the results.

4.4 Experts' and Novices' CM Quality Differences According to the Subject Matter

Sub RQ 2.3: Are there differences among experts' and novices' CMs in terms of content richness?

In order to determine the differences between expert and novice participants in terms of content richness, their mean scores for the predetermined measures (the number of concepts, links, cross-links and examples) were compared while considering the subject matter affect. The results showed that there was an apparent difference between the experts and novices in terms of the content richness in Cell topic. The number of concepts in expert CMs (*M*=32.67, *SD*=7.64) was higher than the novices (*M*=23.5, *SD*=4.17). In terms of the number of links in the CMs, experts scores were also higher (*M*=38, *SD*=4), than the novices (*M*=22.5, *SD*=6.86). In addition, the number of cross-links (*M*=6, *SD*=0) and examples (M=6, *SD*=2.65) were greater in experts than the novices (*M*=1.83, *SD*=1.85; *M*=1.67, *SD*=3.5). As a result, it was observed that experts' CMs were more qualified according to all measures than the novices in Cell subject. See Table 4.15.

Table 4.15 *Comparison of the Quality Measures for Expert and Novice Participants (Cell)*

Cell		Number of concepts		Number of links		Number of cross-links		Number of examples	
	N	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Experts	3	32.67	7.64	38	4	6	0	6	2.65
Novices	12	23.5	4.17	22.5	6.86	1.83	1.85	1.67	3.50

The quality measures differences between the expert and novice participants were also shown in the figure 4.11 for Cell subject. The number of concepts, links, cross-links and examples values was higher in experts' CMs than novices' CMs.

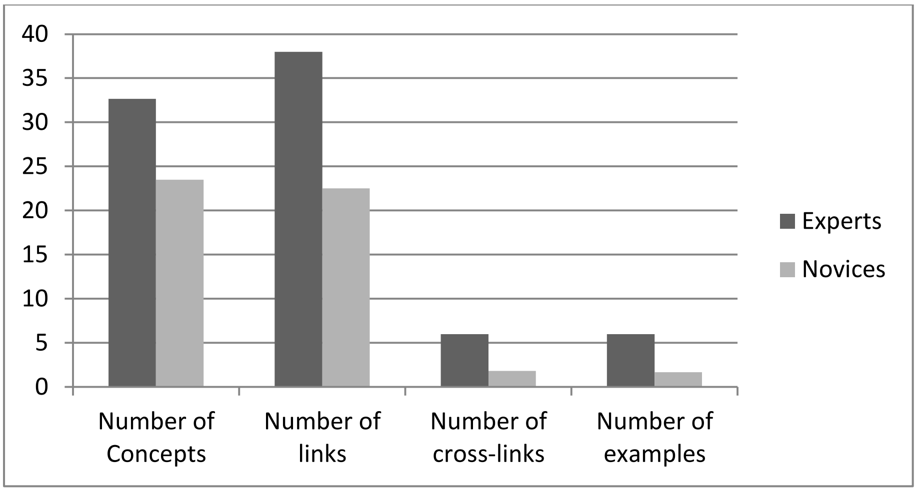


Figure 4.11 Differences between Number of Concepts, Links, Cross-links and Examples According to Expertise (Cell)

The results showed that there was also an apparent difference between expert and novice participants in terms of the content richness for Matter subject. The number of concepts in expert maps were higher (*M*=30.33, *SD*=12.42) than the novices (*M*=17.4, *SD*=3.85). In addition, the number of links included in CMs were also higher in experts (*M*=30, *SD*=9.64) than the novices (*M*=19.4, *SD*=6.07). Furthermore, the number of cross-links (*M*=2.33, *SD*=2.08) and examples (M=7, *SD*=4) were also higher in experts than the novices (*M*=2.13, *SD*=2.17; *M*=1.46, *SD*=2.53). As a result, experts' CMs were more qualified according to all measures than the novices. This was clear that, experts' CMs were more qualified in all measures than the novices in Matter subject. See Table 4.16.

Table 4.16 *Comparison of the Quality Measures for Expert and Novice Participants (Matter)*

Matter		Number of concepts		Number of links		Number of cross-links		Number of examples	
	N	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Experts	3	30.33	12.42	30	9.64	2.33	2.08	7	4
Novices	17	17.4	3.85	19.4	6.07	2.13	2.17	1.46	2.53

The differences between the expert and novice participants for Matter subject were also shown in the figure 4.12.

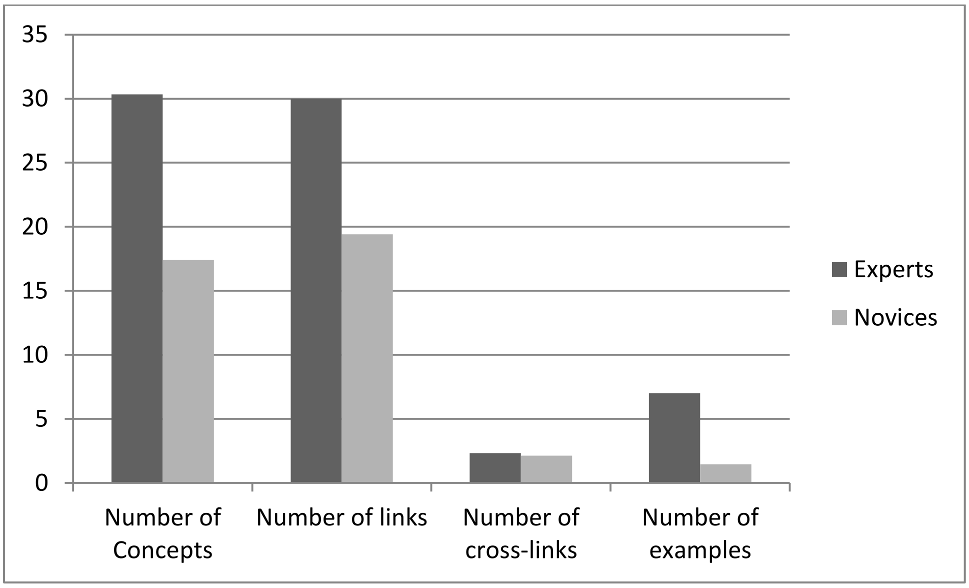


Figure 4. 12 Differences between Number of Concepts, Links, Cross-links and Examples for Different according to Expertise (Matter)

Summary of the Results (4.4)

The analysis of the results showed the following major findings;

- <u>CM quality and content richness:</u> Experts' and novices' CMs were analyzed to determine the quality difference. The analysis for examining the quality of the

CMs while considering the subject matter change showed that, experts' CMs were more qualified than the novices according to the all quality measures (the number of concepts, links, cross-links and examples) independent to the subject matter (Cell and Matter subjects).

4.5 Concept Map Development Pattern Reliability Check within Different Topics

In this section, whether CM development pattern differed according to the topic change was explored. Particularly, general pattern, eye movement pattern, and content richness issues were covered. In order to examine whether CM development process was affected by subject matter difference, two different topics from Biology (Cell) and Chemistry (Matter) were compared. The novice participants who developed CMs in both Matter and Cell topics in the first and second phases of the study were used in the comparison analysis. Participants' general patterns and eye movements were analyzed by using the frequently observed acts during CM development process.

Participants' total time spent during CM development was compared. The results showed that participants' total visit duration during the entire task was distinguished for different topics. In terms of the total time spent on the entire task, participants spent more time in Cell topic than Matter topic. See Figure 4.13.

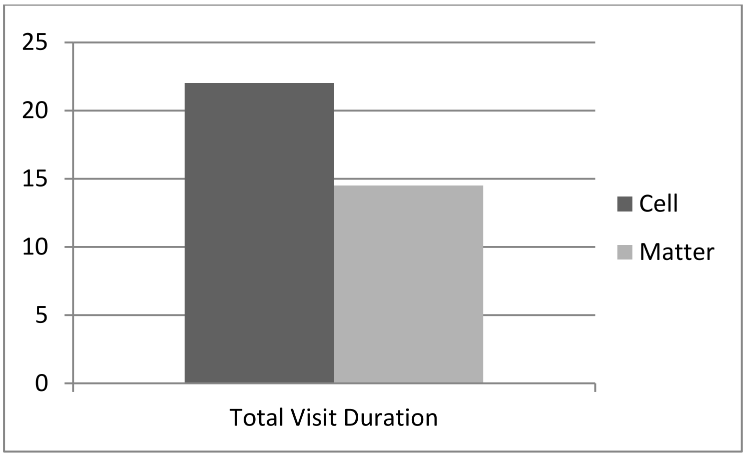


Figure 4. 13 The total visit durations for Matter and Cell topics (*min)

In order to determine whether there were statistically significant differences among participants' FD values for these acts for different topics, the Wilcoxon signed-ranked test was used. The results showed that for some acts there were statistically significant differences between FD values: *controlling and checking* (z= -3.18, $p < .05$), *reasoning act* (z= -3.35, $p < .05$), *constructing a link* (z= -3.41, $p < .05$), *writing into concept* (z= -3.41, $p < .05$), *constructing a blank concept* (z= -3.41, $p < .05$), *using toolbox* (z= -3.24, $p < .05$) and *arrangement acts* (z= -3.41, $p < .05$) in participants' CMs for Matter and Cell topics. The FD for controlling and checking act was higher in Matter topic (X_{Matter}= 1.86, SD= .91) than the Cell topic (X_{Cell}= .08, SD= .13). For reasoning act, FD periods for Cell topic (X_{Cell}= 1.48, SD= .55) were higher than the Matter topic (X_{Matter}=.33, SD= .10). In constructing link act, the FD for Cell topic (X_{Cell}= .85, SD= .14) was higher than the Matter topic (X_{Matter}= .43, SD= .13).

On the other hand, the FD periods for constructing a blank concept act was higher in Cell topic (X_{Cell}=.1.27, SD=.49) than the Matter topic (X_{Matter}=.49, SD=.16). FD values for writing into concept was also higher in Cell topic (X_{Cell}=.79, SD=.23) than the Matter topic (X_{Matter}=.41, SD=.10). The FD values for tool box usage act in Cell topic was also greater (X_{Cell}=1.54, SD=.79) than the Matter subject (X_{Matter}=.27, *SD*=.17). For arrangement act, the FD values for Cell topic was higher (X_{Cell}=1.49, *SD*=.70) than the Matter topic (X_{Matter}=.42, *SD*=.12). See Table 4.17.

Table 4.17 *Comparison of Fixation duration periods on different acts for different topics*

Measures	Matter		Cell				
	X	*SD*	*X*	*SD*	*z*	p	*r*
Controlling &checking	1.86	.91	.08	.13	-3.18	.001*	-.58
Crosslink	.83	.61	.19	.23	-2.76	.006	-.50
Reasoning	1.48	.55	.33	.10	-3.35	.001*	-.61
Revising	.81	.27	.51	.29	-2.39	.017	-.44
Constructing a link	.85	.14	.43	.13	-3.41	.001*	-.62
Writing into concept	.79	.23	.41	.10	-3.41	.001*	-.62
Constructing a blank concept	1.27	.49	.49	.16	-3.41	.001*	-.62
Tool box usage	1.54	.79	.27	.17	-3.24	.001*	-.59
Tool related problems	.84	.49	.66	.37	-.80	.005	.15
Arrangement	1.49	.70	.42	.12	-3.41	.001*	-.62

*p < .05

Content Richness Issues in Different Topics

It was also explored whether there was a quality difference between the two different CMs developed by novices on Cell and Matter topics. While determining the quality difference, the number of concepts, links, crosslinks and examples were compared. The number of concepts in Cell topic (X_{Cell}=28.2, *SD*=5.72) was higher than the *number of concepts* in Matter topic (X_{Matter}=17.4, *SD*=3.85). The number of links in Cell topic (X_{Cell}=28.2, *SD*=5.72) was also higher than the Matter topic (X_{Matter}=20.07, *SD*=4.63). The number of cross-links in Matter topic (X_{Matter}=2.13; *SD*= 2.16) was higher than Cell topic (X_{Cell}=1.73; *SD*=1.94). The number of examples in Matter topic (X_{Matter}=1.47; *SD*= 2.53) was higher than Cell topic (X_{Cell}=.53; *SD*= 1.81). See table 4.18.

Table 4.18 *Comparison of content richness measures for different topics*

Measures	*N=15*	Matter				Cell			
		X	SD	Min	Max	X	SD	Min	Max
Number of concepts		17.4	3.85	12	27	28.2	5.72	17	38
Number of links		20.07	4.63	14	27	27.8	8	15	44
Number of cross-links		2.13	2.16	0	7	1.73	1.94	0	6
Number of examples		1.47	2.53	0	9	.53	1.81	0	4

It was observed that in quality measures except the number of cross-links, CMs developed in Cell topic were comparably richer than Matter topic. In Matter topic, SD values for the number of cross-links and examples were higher than mean values. This may be related with the number of participants who developed CMs in both subjects and the difficulty of constructing cross-links compared to other acts. As it was seen in figure 4.14 the values for different topics were considerably close.

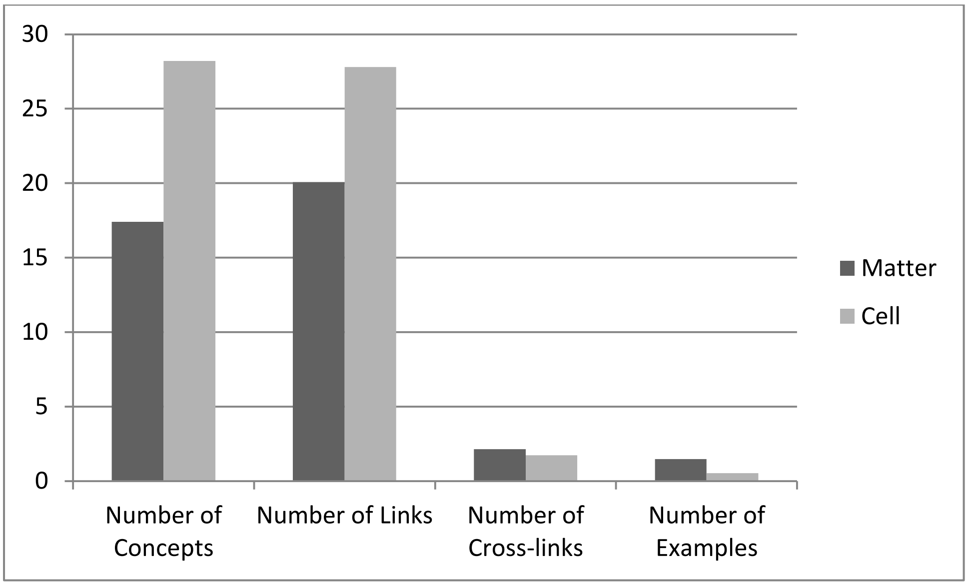


Figure 4. 14 The differences between number of concepts, links, cross-links and examples for different topics (Matter and Cell)

Summary of the Results (4.5)

- In order to explore whether CM development process change according to the subject change (Cell and Matter concepts), participants' CMs were analyzed to see the general pattern, eye behavior pattern and content richness issues. Although the results differed in terms of total visit duration for entire CM development task, in terms of the general pattern followed during CM development process they did not differed. For both topics, they followed a deductive strategy and preferred a hierarchical type mapping in both maps.
- Participants spent more time in in Cell topic than Matter topic while developing their maps. The eye movement analysis results showed that there were statistically significant differences participants' FD values between *controlling and checking*, *reasoning*, *constructing a link*, *writing into concept*, *constructing a blank concept*, *using toolbox* and *arrangement acts*. FD values for controlling checking act was higher in Matter than Cell subject. In reasoning, constructing a link, constructing a blank concept,

writing into concept, using toolbox and arrangement acts participants spent more time in Cell subject than Matter subject.

- The results showed that there were some quality differences in participants' CMs for Cell and Matter concepts. The number of concepts and links were higher in Cell than Matter topic. On the other hand, the number of cross-links and examples were not affected from the topic change like the number of concepts and links. This may be related with the participants' aptitude to that topic and confidence on that topic than the other.

4.6 Progress Pattern Analysis

In addition to the eye movement pattern of the expert and novice participants, the progress pattern among these participants on the different stages of CM development process was explored. For that reason, the total CM development process was divided into four periods. The researcher determined these periods while considering the constructed concept number as a basis. Since the CM completion time was varying between participants from very long time to considerably short periods, time was not considered as a reference point instead accurate number of concepts completed chosen as a basis. The researcher identified *beginning period* whenever a participant finished 25% of the CM (25% of the accurate number of concepts), whenever 50% of the CM was finished this period was identified as *early-mid period* and this continued with %75 as *late-mid period* and %100 as *final period*. For that reason, the researcher explored the absolute frequency and total time spent on these acts during these periods, to determine whether there was a pattern among novice and expert participants. See figure 4.15.

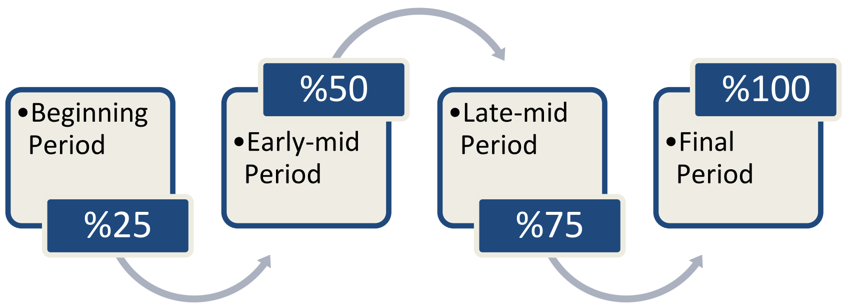


Figure 4. 15 The Determined Periods in CM Development Process

In order to differentiate the periods in terms of the total number of movements observed, novice and expert participants' total number of movements (including all acts) were compared for Cell subject. The highest total number of movements for both groups were the last period ($M_{Novices}$=78, *SD*=39.81; $M_{Experts}$=75.67, *SD*=36.91) for Cell subject. The beginning and final periods' total number of movements were precisely closer to each other than the other periods for novices (*M*=48, *SD*=19.83) and experts (*M*=43, *SD*=14.53). In the late-mid period, there was an appreciable difference among novice and expert participants' total number of movements (*M*=39.75, *SD*= 15.46; *M*=55.33, *SD*=10.41). Minimum and maximum scores for each period and for expert and novice participants were given in Table 4.19 and figure 4.15.

Table 4.19 *Novice and Expert Participants' Total Number of Movements for Each period (Cell)*

	N	Period	*M*	*SD*	Min	Max
Novices	12	1 (Beginning)	48.00	19.83	18.0	79.0
		2 (Early-mid)	52.67	24.94	10	110
		3 (Late-mid)	39.75	15.46	20	66
		4 (Final)	78	39.81	26	161
Experts	3	1 (Beginning)	43.00	14.53	28.0	57.0
		2 (Early-mid)	45	10.58	37	57
		3 (Late-mid)	55.33	10.41	47	67
		4 (Final)	75.67	36.91	36	109

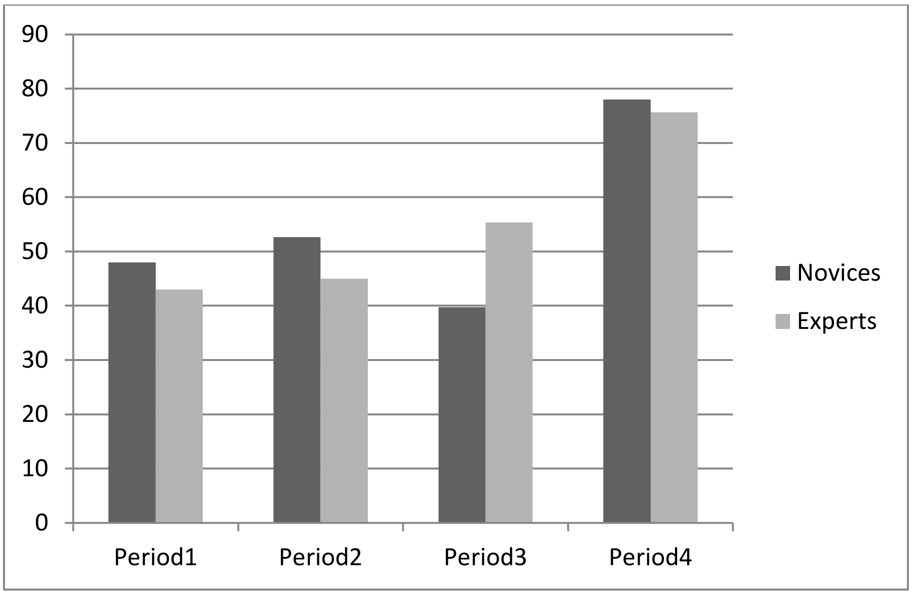


Figure 4. 16 Total Number of Movements for Novices and Experts for Each Period (Cell)

On the other hand, in Matter topic, the difference between novice and expert participants were more apparent in almost every period than Cell topic. Especially there was an appreciable difference between in second ($M_{Novices}$=57.59, *SD*=39.08;

$M_{Experts}$=81, *SD*=38.16) and last periods ($M_{Novices}$=100.82, *SD*=58.33; $M_{Experts}$=131, *SD*=66.09), as experts total number of movements were higher than the novices. The highest number of movements for both groups were the last period like in Cell subject ($M_{Novices}$=100.82, *SD*=58.33, Min=55, Max=280; $M_{Experts}$=131, *SD*=66.09, Min=57, Max=207). See Table 4.20 and figure 4.17.

Table 4.20 *Novice and Expert Participants' Total Number of Movements for Different Periods of the CM Development (Matter)*

	N	Period	*M*	*SD*	Min	Max
Novices	17	1 (Beginning)	32.29	20.55	37	55
		2 (Early-mid)	57.59	39.08	16	148
		3 (Late-mid)	54.18	29.21	11	124
		4 (Final)	100.82	58.33	33	280
Experts	3	1 (Beginning)	44.67	9.29	28	57
		2 (Early-mid)	81	38.16	57	125
		3 (Late-mid)	73	39.89	48	119
		4 (Final)	131	66.09	87	207

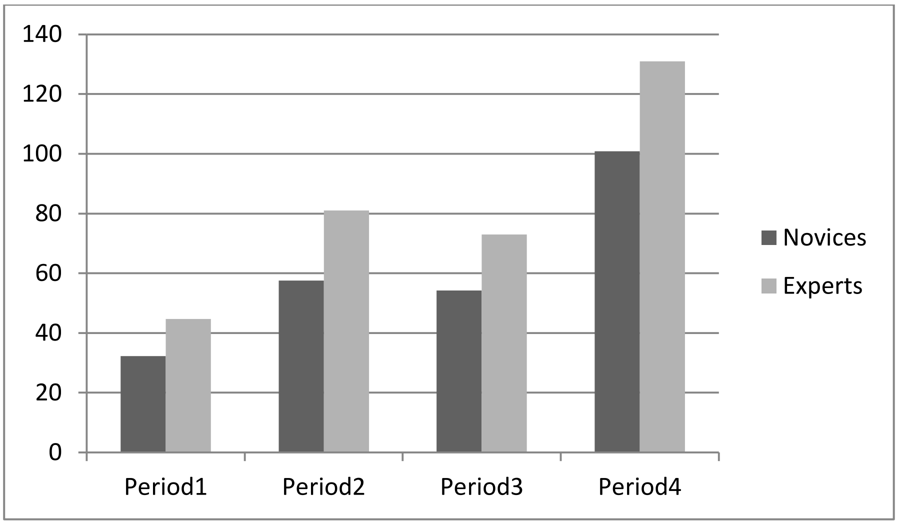


Figure 4. 17 Total Number of Movements for Novices and Experts for Each Period (Matter)

In order to understand whether frequency of specific acts (controlling and checking, cross-link, reasoning and revision) differed in these determined periods between novices and experts, the data compared within these periods. The results showed that there were differences between expert and novice participants in terms of the frequency of these acts in four periods. For controlling and checking act, novices preferred to control their maps in every period while experts tended to control in mostly in early-mid and final periods. Expert participants did not control or check their CMs in the beginning period while novices controlled their maps but lesser than the other periods. In addition, the frequency of the novices for controlling and checking act was higher than experts in beginning, late-mid and final periods. For constructing cross-links, a similar pattern was observed for novice participants. They tended to construct cross-links in every period, while experts constructed cross-links in every period except the beginning period. The results also showed that experts constructed more cross-links than the novices. In reasoning act, both novices' and experts' frequencies showed a similar pattern except the early-mid period. In early-mid period, novices showed a leap. Both novices and experts tended to show a higher frequency for reasoning act than the other acts in every period. Experts tended to think in many periods more frequently than the novices. For the revision act, it was seen that there was a different pattern among novices and experts. Novice participants tended to revise their maps in every period more than the experts. Revision was the most frequently observed for both groups of participants in the final period. To sum up, the findings showed that the frequency number was varying for these acts in different periods for novice and expert participants. See figure 4.18.

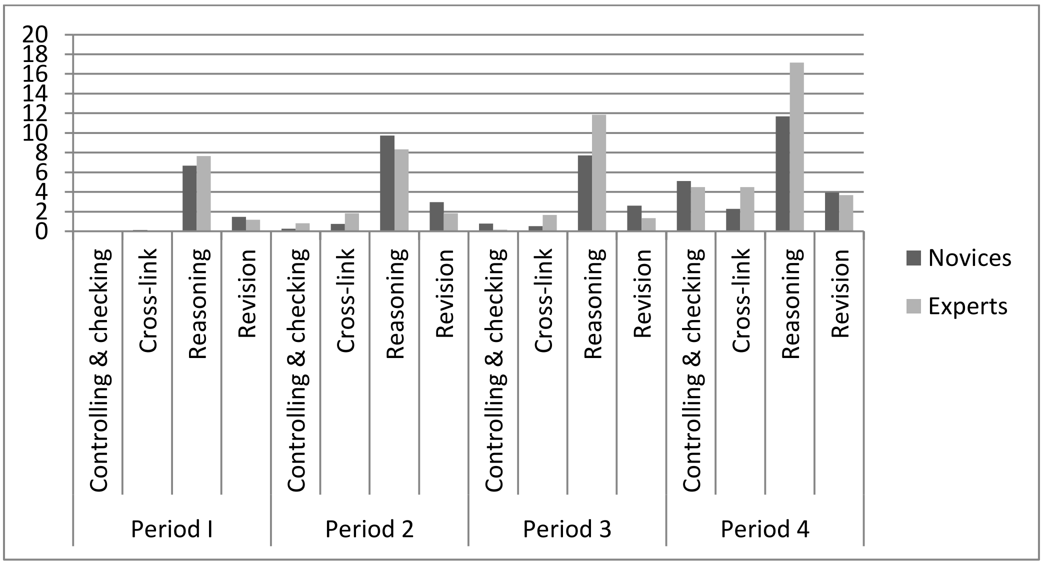


Figure 4. 18 The Frequency of Some Acts in Each Period According to Expertise

Although the frequency number is a good reference point for determining the pattern between the participants, the durations spent in every period were determined. The duration values proved that although the frequencies of some acts were higher for some acts, it was required to determine the duration numbers to see the exact pattern. The results showed that although for the first and second periods the durations were parallel, in the third period although experts controlled their CMs few times, novices and experts spent closer period of times. On the other hand, in the last period the time spent for controlling and checking act was higher for experts than novices. For cross-link the frequency and the time spent for this act were almost parallel, except the early-mid period. In this period, although experts tended to develop more cross-links than the novices, novices spent equal time to experts. This might be related with the difficult nature of constructing cross-links and novices' several attempts for constructing cross-links during CM development process. The total time spent and the frequency of reasoning act in every period were similar in the late-mid and final periods. However, in the beginning period although experts' reasoning frequency was higher than the novices, the total time spent on this act was very close to experts. On the other hand, a reverse situation was observed in the early-mid period. Although novices' frequency number was higher than novices, the total spent time was very close to experts. For the revision act, a parallel pattern was observed like in the frequency pattern, except the final period. In the final period, although experts less revised their CMs, they spent more time than the novices. See figure 4.19.

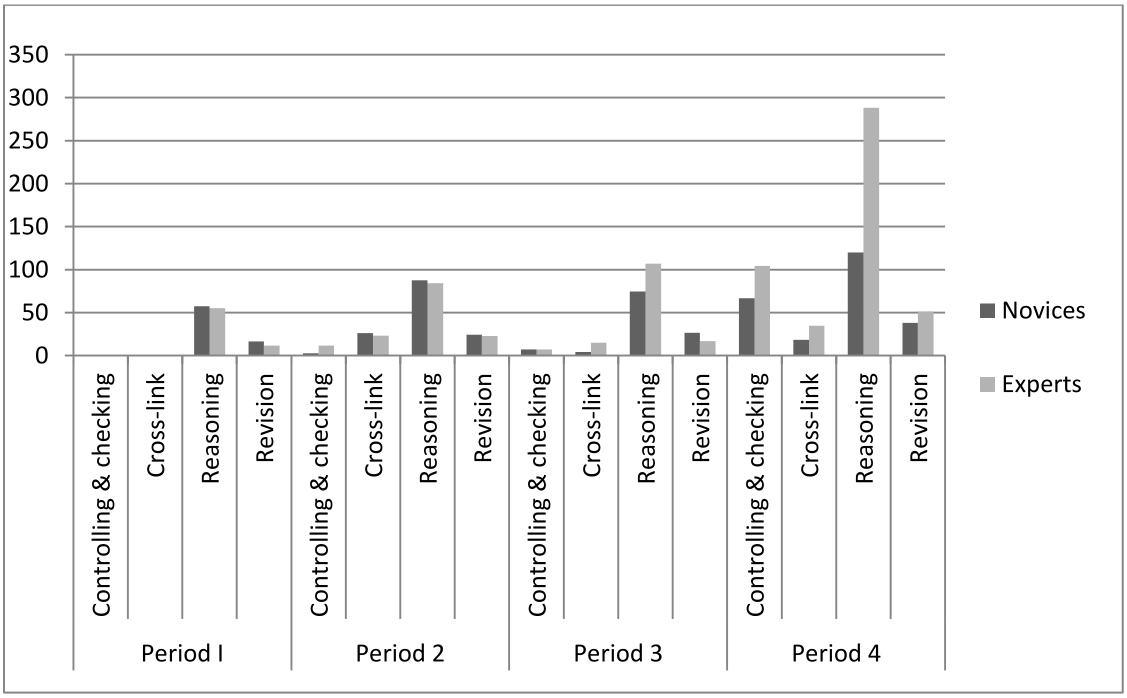


Figure 4. 19 The Total Time Spent for Each act in Every Period According to Expertise

Summary of the Results (Section 4.6)

- In order to explore the progress pattern among participants the researcher divided the CM development process into four periods; beginning, early-mid, late-mid and final periods. The frequency of the every act and their distribution in these periods were examined. The analysis showed that the highest total number of movements for both expert and novices were the last period for Cell topic. The beginning and final periods' total number of movements precisely closer to each other than the other periods for novices and experts. In the late-mid period, there was an appreciable difference among novice and expert participants' total number of movements. The results for Matter topic showed that experts and novices differed almost in every period than Cell topic. Especially the differences between in early-mid and final period's total number of movements were higher for experts than novices. The highest number of movements for both groups was the final period for Matter topic which was similar for Cell topic.
- Furthermore, the frequency of specific acts and the total time for these acts were explored. In addition to the general process pattern whether there were differences between experts and novices in terms of the frequency in four periods for specific acts explored. The findings showed that the frequency number was varying for these selected acts in different periods for novice and expert participants. There were different patterns observed for these groups in different periods.
    - <u>Controlling and checking:</u> The frequency of the novices for controlling and checking act was higher than the experts in the beginning, late-mid and final periods. It was observed that novices tended to control their CMs in every period while experts preferred to make this controlling and checking act mostly in the early-mid and final periods. Experts did not prefer to control their maps especially in the beginning period while novices controlled their maps in this period but slightly lesser than the other periods.

- Cross-links: Similar pattern was observed in constructing cross-links for novices. Novices preferred to construct cross-links in every period although their number of cross links was lesser than the experts. Their attempts for constructing cross-links increased the number of acts. Novices tended to construct cross-links in every period while experts preferred to construct cross-links in early-mid, late-mid and final periods.
- Reasoning: The frequency for reasoning act was higher than the other acts for both novices and experts. Except the early-mid period, both novices and experts showed a very similar progress pattern for reasoning act. Especially in the final period, it was observed that novices showed a dramatic increase for reasoning act than the other periods. The results showed that experts tended to think in many periods and more frequently than the novices.
- Revision: It was observed that experts and novices showed a different pattern while revising their CMs. The revision frequency was higher in novices than experts and they tended to revise their maps in every period. The most frequent observation of revision act was final period for both novices and experts.

- In addition to the frequency number for specific acts for novices and experts, their total time spent in every period was explored to determine the exact pattern.
    - Controlling and checking: According to results, the total time spent and frequency numbers for the beginning and early-mid periods showed a parallel manner. However, in the late-mid period although experts controlled their CMs fewer than the novices, their total spent time was close to each other. On the other hand, in the final period, experts spent considerably long time for controlling and checking act than the novices.
    - Cross-link: The frequency and total time spent for the cross-link act were almost parallel, except the early-mid period. In this period, although experts tended to develop more cross-links than the novices, novices

spent equal time to experts. This might be related with difficult nature of constructing cross-links and the several attemps of the novices for constructing cross-links.

- Reasoning: The total time spent for reasoning act in every period showed a similar pattern except the beginning and early-mid periods. In the beginning period although experts' reasoning frequency was higher than the novices, the total time spent on this act was very close to experts. On the other hand, a reverse situation was observed in the early-mid period, although novices' frequency number was higher, the total time spent for this act was very close to experts.
- Revision: A parallel pattern was observed for the revision act like in the frequency pattern, except the final period. In the final period, although experts less revised their CMs, they spent more time than the novices.

4.7 Other Factors that Affect the CM Development Process

RQ5: What are the factors that affect experts' and novices' CM development process?

Subject Matter Selection and Its Effect on CM Development Process

Written data were collected to explore whether CM development process affected by subject matter change. According to them, subject selection was an important issue during CM development process since it affects the process directly. The written data showed that, most of the novice participants (N=23) pointed out that, the process was affected by the subject selection. However, some participants (N=5) expressed the opposite, as the process was not affected from the subject matter change directly. The results showed that familiarity to the subject matter eased the process and shortened the time period spent for completing the CM. They also indicated that suitability of the subject in terms of branching was another important issue. They expressed that they prefered familiar and general subject matters, because they felt confident on these subjects which decreases the fear of making mistakes. A few participants remarked that sometimes selecting a general subject matter might cause an organization problem, since they had various branching options in it and it caused chaos on the visual representation. Some of the participants' views were as;

> 'Since I am familiar to the subject, the concepts and relations were very explicit in my mind. I would not develop a concept map in a newly introduced topic smoothly.' (N8)
>
> 'Bildiğim bir konu olduğu için kavramlar ve ilişkiler kafamda daha netti. Yeni karşılaştığım bir konuda bu kadar rahat yapamayabilirdim.'
>
> 'Yes, the subject matter affected the process. Because, cell subject which could be explained under several branches, such as prokaryotic, eukaryotic, plant, animal cell, organelles and so on. For that reason it was easier for me.' (N13)
>
> 'Evet, süreci etkiledi. Çünkü hücre dallandırılabilecek bir konuydu. Mesela prokaryot, ökaryot, bitki, hayvan hücreleri, organelleri vb. gibi o yüzden daha kolay oldu.'

Cmap Tool or Paper and Pencil

The results showed that all participants were eager to use computer bsed tools (e.g Cmap Tool) than developing their maps with paper and pencil. Only one participant indicated that it depends on the nature of subject matter, it is possible to develop first in paper and then develop by using a computer based tool. The main reason for choosing Cmap Tool instead of paper and pencil, it was more cost efficient, easy to use, enable representing the information in a well structured and designed way, provide chance to add or remove any information without a time and space concern. One of the novice participants explained the easiness of Cmap tool as;

> 'You can't adjust the size of the concept map while developing on paper, you have no choice to delete or arrange something written bigger than the others. In Cmap Tool, you can arrange anything very easily, can move to anywhere on the screen. For example, in paper you can't change your mind cannot change the places of concepts easily. On the other hand, concept maps allow user to change the concepts and move anywhere. If there is a mass in concept map, you can change them, easy to use. Paper is not like that. If you would like to have a smooth concept map, you have to make a plan every detail first, and then you can draw on paper. But, Cmap Tool is

> not like that, even I made this concept map in a short period of time, this is not a bad looking one. I can add something at once; can move to anywhere and very easy to use. You can do anything you want, whenever you remembered something new.' (Novice14)

> 'Kağıtta hazırlarken boyutlarını ayarlayamıyorsun, bir anda çok büyük yazdığın bir şeyi filan silip düzeltme şansın yok. Burada herşeyi cok rahat silip düzeltebiliyorsun, istediğin yere koyabiliyorsun. Mesela vazgeçip bunu buraya alacağım diyemiyorsun, orada kalsın bir anda bir yer sıkışık olabiliyor, ama cmap'de öyle birşey yok istediğin gibi değistirebilirsin, yerini ayarlayabilirsin. Baktın şekiller bir yere toplanmış, öbür tarafa alabilirsin, kullanımı kolay ve güzel. Kağıt gibi degil mesela. Kağıtta yaparken herşey bir kere, cmap'in mesela şu özelliği var herşeyi planlayıp kağıda dökmelisin, düzgün olmasını istiyorsan cmap'in görüntüsü güzel birşey olmasını istiyorsan, herşeyi tasarladıktan sonra en ufak ayrıntıyı dahi hesapladıktan sonra kağıda çizmen lazım ki bir yerinde bir hata çıkmasın. Toparlaması kolay olmuyor. Ama cmap tool öyle değil, şimdi bile yaptığım cmap çok güzel bir şekle sahip, çok da kötü durmayan güzel bir cmap. Bir anda ekleyebiliyorum, istediğim yere koyabiliyorum, çok rahat oluyor, insan öyle kasmak zorunda kalmıyor. Bir anda hepsini yapabiliyor, aklına geldikçe.'

The experiences of the participants showed the favorable nature of Cmap Tool which was approved by many participants. According to them, its' facilitative structure helped them to arrange their maps easily and smootly. Furthermore, it enabled them to develop better CMs with less effort considered to paper and pencil maps.

Language Effect on CM development Process (Turkish and English)

The language effect on CM development process was another explored issue to determine the factors that affect CM development process. To determine the views of the participants on this issue verbal data collected on their language preferences for CM development. Most of the participants (N=11) reported that they did not develop a CM in Turkish. Only 3 participants developed CM in Turkish before attending this study. Although most of the participants did not develop a Turkish CM, they stated, they have encountered with Turkish CMs. The results showed that, if they had an option in this study to select the language of their maps, most of the participants would select English rather than Turkish. Only 4 participants were willing to develop CMs in Turkish. Other participants specified the problems could occur during CM development in Turkish. The most common indicated reason was related with the language structure. English language is more convenient than Turkish language for CM development, since verbal structure was totally different in Turkish language. Finding proper linking words and representing the knowledge would be the potential problems for Turkish CMs. According to them, especially younger age students would not understand the aim of CM because of the Turkish language structure.

> 'I think, concept maps are different, in the sentence the verb is in the middle in English and this might be confusing for students and they could be baffled in Turkish maps.' (Novice16)

> 'Yani, concept map biraz daha farklı olduğu için, fiil ortada oluyor İngilizce gibi öğrencilerin kafası daha çok karışabilir Türkçe concept map'lerde diye düşünüyorum.'

> 'For now, developing concept map in English is easier, but it is necessary to examine the books for example the teacher books. From that point, developing a Turkish concept map could be easier for many people, but if you asked my opinion, I would prepare English, it is easier for me. Since, in English the linking words are short, and only one word, you can link two concepts with using only a word like "in". You can link words by only using "is" or "as" easily, for that reason, it seems like easier. However, in Turkish it is hard to find a proper linking word, and we are estranged from Turkish a little bit.' (Novice17)

> 'Şu an için İngilizce hazırlamak daha kolay bir de kitapları incelemek gerekiyor hani o şeyleri, öğretmen kitapları filan hani olur ya. Oradan bakınca belki Türkçe hazırlamak daha kolay olabilir ama şu an için sorarsanız Türkçe'mi hazırlayayım İngilizce mi hazırlayayım İngilizce hazırlamak daha kolay gibime geliyor, o yüzden İngilizce'yi tercih ediyorum. Çünkü İngilizce'de bağlaçlar (ilişki kelimeleri) çok kısa, bir tek kelime mesela 'in' ile iki kavramı birbirine bağlayabiliyorsunuz. Baktığınızda 'is' ile ya da 'as' ile bağlayabiliyorsunuz, o yüzden daha kolay geliyor. Ama Türkçe'de böyle birşey bulmakta zorlanabilirim, bir de Türkçe'den uzaklaştık biraz.'

Similar to the novice participants' views on using CMs in Turkish, all the experts (N=5) had the same opinion about using CMs in Turkish might not be appropriate. CMs were not suitable for Turkish language because of its grammar structure. Specifically the common mentioned problem during the development was related with the verb position in the sentence which was different in English than Turkish.

All the experts agreed that in English the linking words were being used different than Turkish language. In Turkish, the verb was placed at the end in the sentence but in CMs these words were being used as linking words and placed in the middle. One of the experts explained this issue as;

> 'Yes, the concept maps were being used in Turkish, but they do not reflect a real concept map. Since these concept maps are not suitable for the purpose of it. The important point in concept mapping is to see the concept and the relations among them. In addition, in English, the relation is written on the arrow. However, conversely to English, in Turkish subject and verb have a different position in sentence, and it became an inverted sentence. I think it impairs the Turkish, and meaningless. It could cause damage instead of taking an advantage. I think a different thing need to be developed for Turkish language. Because, it is very useful tool, I think students can gain many insights from the tools like concept maps.' (Expert3)
>
> 'Evet, ama pek gerçek bir kavram haritasını yansıtmıyor. Çünkü kavam haritasının amacına çok uygun değil. Kavram haritasında önemli olan kavramlar ve arasındaki ilişkileri görmektir. Bir de ilişkinin cinsi de şeye yazılır ya line'in üzerine ama Türkçe'de özne ve yüklemin yerleri farklı olduğu için İngilizce'den, devrik bir cümle oluyor. Türkçe'yi bozuyor ve anlamsız oluyor bence. Faydasından çok zararı da dokunabilir. Bu kadar devrik birşeyin, bence. Turkce'yi bozuyor çünkü. Ya da farklı birşeyler geliştirilmeli, bilmiyorum Türkçe'ye kazandırmak için. Çünkü çok güzel bir tool, çok faydalı bir tool, öğrenciye çok şey kazandıracağını düşünüyorum.'

Challenges and Obstacles Experienced

CM development is a complex process which requires integrating new information into prior knowledge which is poured into visual representation. Although some thought developing CM is easier than writing a text, CM developer need to be well accustomed to the developing process. The written data collected from novice participants showed that 21 out of 29 participants stated that they had experienced problems during their CM development processes. Even though the participants were aware of how to develop a CM with paper and pencil and experienced the Cmap Tool in the training session before the real study, some participants (N=9) indicated that they had some difficulties related with the tool familiarity. Many of the participants expressed that since they were not using the tool frequently they had some problems during the process like drag and drop acts and connecting a concept appropriately. This showed that like every tool Cmap Tool requires an adaptation process which would vary. Hence this adaptation problem might have caused the problems and ineffective usage.

The observations of the researcher were consistent with the participants' statements. Problems related with the Cmap Tool divided into two categories; concept and link oriented. The first one was mainly related with the constructing a concept, some of the participants had problems while writing the concepts; clicking twice on CM developing screen caused more than one concept although the aim was to write sub concepts under these arrows. The other problem was related with the process of writing on the link line that whenever they touched to the keyboard or mouse the writing place became invisible and that causes an error. Instead of writing the link word, some of the participants composed more than one links and this caused a misconception for them while forming the links. These problems were all about the tool related that the participants needed a period of time for adopting the tool. In addition to this, some participants' gaze replay (N=2) showed that they had also problems associated with the forming the concepts with double clicking which confused them. For this reason, some of them deleted some of the concepts or branches several times and re-constructed them.

The verbal protocol data also showed that the situation was similar between novices and experts; all participants considered the Cmap Tool was easy to use; but they experienced problems during the CM development process. The main problem among experts was to drag and drop actions while connecting a concept with another one. They explained that whenever they tried to connect a concept with an existing one, a new concept occurred. Furthermore, because of their extended knowledge on the subject they tend to include more concept and relations than the novices. This caused an organization problem related with the visual representation of the CM. One of the experts explained her idea about the usability of Cmap Tool as;

> ‘Actually it is not hard to use but it requires practicing. I mean, dragging the arrows, I could not find the arrows for a moment then I was dragging the arrows and they disappeared. I spent huge time to find the arrows.’ (Expert3)
>
> ‘Aslında zor değil ama, pratik yapmak gerektiriyor. Yani okları çekmek, bir an okları bulamadım tutuyorum bir bakıyorum tekrar yok. Hani okları bulmak için de baya bir zaman harcadım.’

Other mostly mentioned problems among novices were organizing the information appropriately (N=7) and being confident about the adequateness of the information included in CM (N=3). Expert participants expressed the main problem during CM development was tool related and this caused also an organization problem during their mapping process.

English proficiency level also effected the CM development process as some novice participants (N=4) mentioned. Written data proved that most of the participants (N=7) had problem during CM development process because of their limited English vocabulary. They had problems about remembering the required concepts and relations. They also expressed that this problem was both related with the selected subject matter and their language proficiency level. Since they had to construct CMs in English, they faced some language related problems like difficulty in remembering an appropriate word. As a result of this, they stated they could not express the relation appropriately and they used the same relation word several times. According to them, they would feel more confident with another topic and the process would be easier for them.

Summary of the Results (Section 4.7)

- The results showed that subject selection was considered as an important issue which affects the process directly. Being familiar to the subject matter eased the process and shortened the completion time. Familiar and general subjects preferred by participants since they felt confident on the subject and made fewer mistakes. The suitability of the subject in terms of branching was another indicated issue by participants.

- In terms of the applicability of computer based CM tools, they preferred to use computer based tools rather than the paper and pencil. The main reasons for preferring computer based tool (e.g. CMap tool), it was more cost efficient, easy to use, enable representing the information in a well-structured way, easy to add or delete information into CM.
- Although they preferred computer based tools like Cmap tool, they had faced with some problems which was tool related. Most common mentioned problem by both experts and novices during the CM development process was related with the tool familiarity. The other mentioned problem was organizing information appropriately and the adequateness of the CM in terms of the information included. For the novice participants, their limited vocabulary affected their CM development process directly, and caused repeating some linking words several times.
- Language of the CM was another factor affected the CM development process mentioned by novice participants. Most of the participants did not experience CMs in Turkish but they stated that they have encountered with Turkish CMs. According to the results, most of the participants preferred to develop CM in English instead of Turkish. The most common indicated reason was the language structure difference. They considered English was more convenient than Turkish for CM development. According to them, finding proper linking words and representing the knowledge would be the potential problems for Turkish CMs. Experts also shared this view; the grammar structure of Turkish language was not suitable for CM development. The verb position was different in Turkish than English.

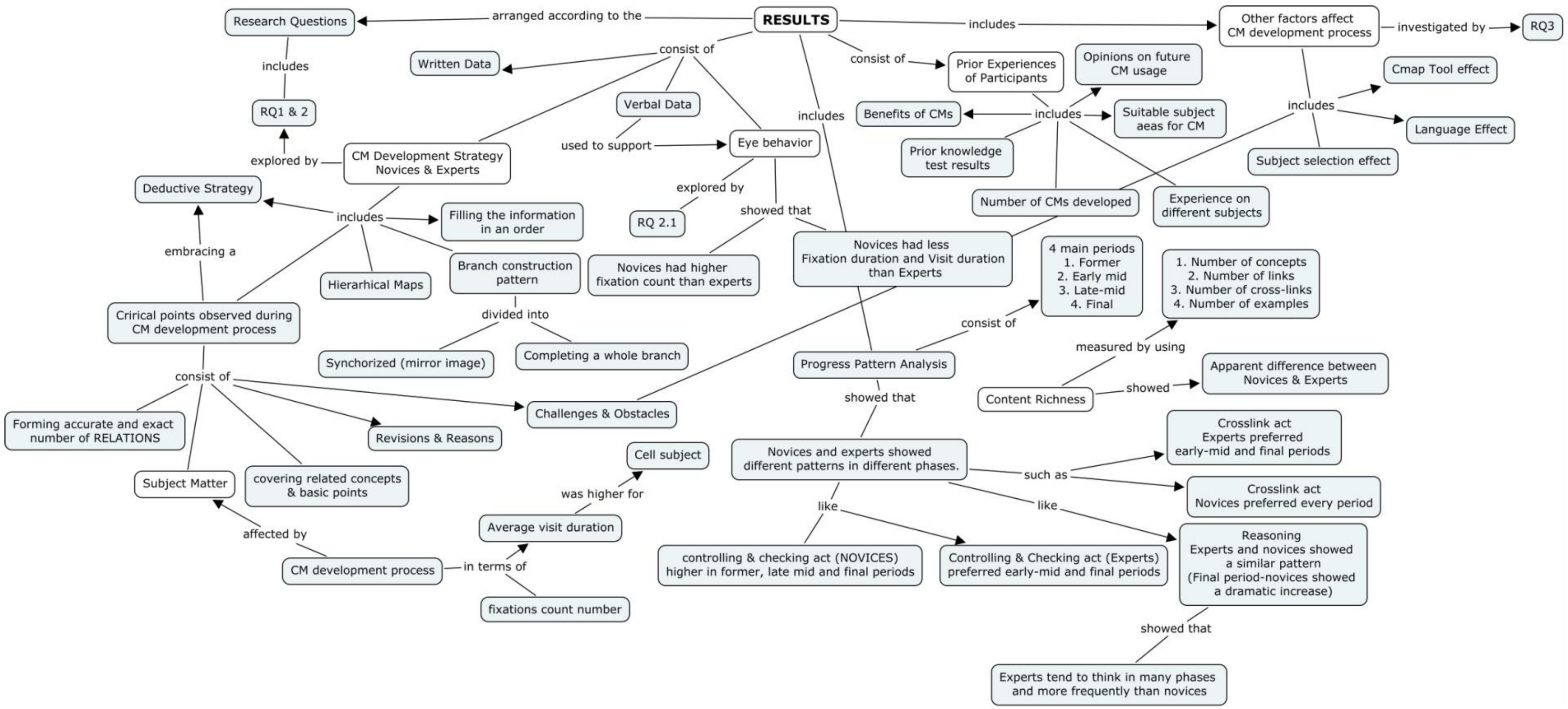


Figure 4.20 Summary of the Results

CHAPTER 5

DISCUSSION AND CONCLUSION

'Every new thought that he hears or reads of' appears to him 'immediately in the form of a chain.'(Nietzsche, 1969, p. 864)

In this chapter, it is aimed to summarize the findings and to discuss them within the framework of the existing literature. In conclusion, while considering the limitations of the study, possible future research opportunities and recommendations for effective use of CMs are offered.

The purpose of this study was to explore how novices and experts established the CM development process. Two experiments were conducted to determine whether novices and experts had a specific strategy during the CM development process and how they differentiated from each other during this process. In order to examine the existing pattern among participants' written, verbal and eye movement data were collected and analyzed. The written data were gathered through two open-ended questionnaires related with participants' prior experiences and views on CM and their self-reports on CM development process. Before the real experiments, pilot studies were conducted with both novices and experts. In these pilot studies, first a prior knowledge test and inventory instrument were administered to the participants and then their eye movements were recorded to gather information on their cognitive processes. After examining the pilot study, the limitations of investigating only eye movements for betraying cognitive process were realized. Making interpretations on participants' cognitive process only based on the visualizations from eye movements could be misleading. For that reason, in the main study, Phase 1, in addition to the eye movement, written data was collected from a new group of participants consisting of 12 pre-service teachers. They were first asked to report their prior experiences on CM development process and subject matter (Cell), and then they were asked to develop a CM on Cell subject. During this process, their eye movements were recorded. Then, in order to have a better understanding on their cognitive processes, they were asked to self-report their strategies and feelings with the aid of an 'interpretative essay' instrument. However, the data showed that the participants did not explicitly explain their strategies and clues regarding this process. Participants who were asked to write down their interpretative essays were too fatigued after the tests that their responses formed insufficient in terms of supporting the eye behavior data. For that reason, they were asked to attend again to the second phase of the study. This time, in addition to the group of participants attended to the first phase, a new group of participants consisting of 17 participants attended to the Phase 2. They were asked to follow a verbal protocol instead of writing about their strategies and feelings during the CM development on Cell and Matter topics. The gathered data were analyzed by using both quantitative and qualitative techniques.

5.1 Prior Experiences on Concept Mapping

The potential of CMs as an educational diagram was explored in the literature by many authors (Jonassen, 2000; Novak, 2005; Nespit & Adesope, 2006). CMs are valuable tools to represent an individual's embraced concept and propositions explicitly. This may enable the teachers not only exchange the ideas with learners but also identifying the missing points and the appropriateness of particular propositions (Novak & Gowin, 1984).

In order to understand participants' views about the potential of CMs in education, their prior experiences and preferences on CM usage and its benefits were explored. The prior knowledge test and CM inventory findings showed that novice participants had the required prior knowledge on the selected subjects and concept mapping activity. It was seen that he prior experiences of participants on CM development process were mostly on science related subjects: Biology, Physics and Chemistry. In terms of the type of CM, spider and hierarchical CM types were preferred most preferred types. Also, it was noted that the participants were more inclined to use the spider type instead of the hierarchical type maps as proved by the written data. The reasons for preferring spider maps were related to its effectiveness, easily recognizable structure and its flexibility to produce more creative products. However, their actual usage of CM types was not parallel to their preferences. They tended to use hierarchical type maps in their mapping process although they expressed they prefer to use spider type maps. This might be related with the suitable nature of the selected content to the hierarchical mapping. When the content was considered hierarchical maps were found very applicable, easy to represent visually and easy to check misconceptions. Hierarchical mapping was also supported by Novak and Canas (2008) as they expressed the effectiveness and importance of hierarchical CMs.

Participants' preferences on CM usage in their active teaching life were consistent with their prior experiences. Most of them were willing to use CM in their active teaching life. Additionally, future preferences in their active teaching life were explored, which was similar to their prior experiences. They considered science related subjects to be more appropriate for CM development. They also mentioned the suitability of subjects related with social sciences. The underlying reasons for choosing subject matter that had a vast number of concepts and the subject matter's suitabilility to develop CM. The reasons for using CM in education were also explained by the participants as, providing a means for seeing the whole picture, having a memorable structure, enabling to summarizethe subject easily, checking misconceptions, using it as an assessment tool that reinforces the subject. The results were consistent with the literature, the potential of CMs for determining the misconceptions (Tekkaya, 2002; Sungur, 2000) and finding the potential gaps in thinking mechanism (Howard & Borton, 1986) assessing the existing knowledge (Ruiz-Primo, Shavelson & Shultz, 2001; Schaal, Bagner & Girwidz, 2010), and using for evaluation purposes (Streeter, Franklin, Kim & Tripodi, 2011).

Furthermore, experts' views were parallel to novices; according to them CMs could be used in every stage of the lesson; introducing a new concept, reviewing a previous one or checking the misconceptions. Teaching a subject by using CM was another mentioned issue by experts. They all agreed on the potential of CMs to be used for reviewing or summarizing. The potential of CMs for introducing or summarizing the subject and addressing the visual memory and preventing misconceptions were also supported by the literature. Novak and Gowin (1984) expressed that CMs could be used as an assessment tool to evaluate what has been learned (Novak & Gowin, 1984), and they are valuable tools for tracing the conceptual development process (Novak, 2005). In addition, CMs are considered a promising instructional strategy for assisting meaningful learning (Novak & Gowin, 1984; Novak, 1990) and determining misconceptions (Novak & Gowin, 1984; Sungur, Tekkaya & Geban, 2001; Tekkaya, 2002, 2003; Kinchin & Hay, 2000). Tekkaya (2002) also expressed the value of CM developed by each student as 'an excellent way of not only the reviewing a given topic but also detecting students' specific misconceptions' (p. 263). Easiness of following information than the other methods as CM allows users to see the big picture was also mentioned issue by the expert participants.

5.2 Concept Map Development Strategy (RQ1 and RQ2)

<u>RQ1: Do novices and experts use specific strategies during the concept map development process? /RQ2: How does the concept map development processes differ between novices and experts?</u>

In the first and second research questions, the differences between novices and experts during CM development process and the specific strategies that they used were explored. Moreover, their eye movement patterns and differences in their eye movement metrics were examined. Furthermore, CMs analyzed with respect to the content richness criteria to determine the possible differences between novices and experts. To explore these questions; written, verbal and eye movement data were collected from the participants. By using interpretative essay questions their general and initial strategies were examined. Eye movement data enabled the researcher to examine the entire process both qualitatively and quantitatively. Besides, although eye movement data is robust, it is not valid to make definite inferences about the cognitive process of the participants which is based on just eye behavior. For that reason, the researcher collected verbal data to validate the inferences based on eye movement data.

The results showed that a common strategy observed among novices and experts was the '*deductive strategy*' which includes starting with a general concept at the first step and afterwards continuing with constructing sub-concepts and links while keeping the main concept in mind. Underlying reasons for preferring a deductive strategy were found as: relations and concepts were structured more easily and smoothly, participants considered the deductive thinking as a learned habit, the selected subjects were parallel to the images that have formed in their mind. In the literature, some of the studies indicated that experts and novices had different reasoning strategies and their frequency to use these strategies differed (e.g. Groen & Patel, 1985 cited in Hoffman & Militello, 2008). Conversely, the findings showed that experts and novices followed a similar pattern of deductive reasoning strategy. The similarity between the expert and novice group in their special reasoning process might be related with the nature of the subject. Furthermore, the novices might imitate their instructors that might affect their reasoning strategy during CM development process. Although they did not distinguished in their general strategy during CM development process, the knowledge organization and the information used in the maps differed.

According to Davidson and Sternberg (2003), experts and novices differ when their competencies were compared. “Experts display greater use of hierarchical knowledge when formulating strategic solutions, greater use and self-monitoring of strategies, more accurate self-evaluation, and greater motivation than novices” (Davidson & Sternberg, 2003, p.238). In addition, they mentioned the importance of self-regulation and the relation to better problem solving process.

In terms of filling the information, both novices and experts followed a *deductive order*, first they filled the concept boxes and then they pointed out the relation word and continued on by moving to the next. Filling the information by following a specific pattern might be related with the processing order in the mind. It was assumed that information is placed in the brain in a specific order, where the grouping of related concepts is important. The participants might fill the CM because of this unrealized grouping in mind or their previously learned behavior until that time by their instructors. This might also be taught them by their instructors how they need to fill information or how to construct CMs previously. This learned behavior from their instructors might also be a reason of their observed pattern.

Furthermore for some participants who lacked the needed knowledge, connecting the concepts with a suitable phrase proved problematic. Since finding a proper linking word requires a specific background in English and the subject matter, most of the participants might not be able to remember appropriate English linking words. This might be result in problems with connecting the concepts, repeating some linking words or preferring write into concept instead of linking word. As a result of this, some participants preferred to write into concepts first and then fill the linking word boxes afterwards.

Moreover, other observed patterns were embracing hierarchical and spider maps and constructing branches. Preferring hierarchical maps could be related to the embracing strategy of ‘deductive reasoning’ which is a top-down strategy and the suitability of the nature of subject to hierarchical mapping. The importance and practicality of using hierarchical mapping was emphasized in the literature. Novak and Gowin (1984) argued that CMs need to be in a hierarchical manner. They also expressed the similarity of a hierarchical concept map with the "visual representation of the individuals thought processes" (p.133). According to them, hierarchy enables mapper to add new concepts and links to the hierarchy or construct new branches or differentiating the existing branches (Novak & Gowin, 1984).

Furthermore, Collins and Quillian (1969, 1972) pointed out the importance of organizing the meaning of words in a hierarchical network which is well-known view (cited in Goldstein, 2005) According to Quillian (1968), hierarchical structure is identical with the CM structure which consistsg of nodes and links much like CMs and the relationships among concepts can specify the meaning of the concept. In addition, Amedieu et al. (2009) indicated the positive effect of hierarchically structured CMs on mental effort for both higher and lower prior knowledge participants. They both produced less mental effort with hierarchical structured maps instead of network maps. Preferring hierarchical type maps this might be related with the learned behavior of novices from their instructors. Since Novak style CMs which is mostly in hierarchical structure is preferred by many instructors in Turkey and this might affect the novices' preferences while developing their CMs.

It was also observed that novice participants tended to follow a different branch construction pattern than the experts. Novices preferred to act in a synchronized manner while constructing a branch which is named as 'mirror image', while experts showed a reverse pattern; completing a branch instead of filling equal information under every equal branch. In the literature the differences between experts and novices in terms of the embraced reasoning strategies and the frequency to use these strategies were explored (Groen & Patel, 1985 cited in Hoffman & Militello, 2008). According to Goldstein (2005) novices differ from experts in terms of classifying the problems regarding their similarities whereas experts tend to classify the problems in terms of the general principles. According to Hoffman and Militello (2008), instead of using special reasoning processes, experts distinguished from novices in their knowledge organization and the way that they used this knowledge. They explained that the expert knowledge is specific to their domain of knowledge, very broaden and vastly organized. The difference among novices and experts could be related with the different knowledge organization structures and the embraced strategies during reasoning which was explored in the literature.

The findings showed that for novice participants during the initial stage there was no deliberate strategy for forming CM. It was observed that instead of embracing a planned act or strategy, they tended to write the information which comes to their mind first. However, eye movements and verbal recording on the process showed that they had a strategy that they followed this strategy without being aware of its presence. According to Kuhn and Dean (2004), metacognition is defined as “thinking about thinking”. They emphasized the importance of metacognitive development and explained how metacognitive development of students could be supported. One way to support the metacognitive development is to bear up the learners to “reflect on and evaluate their activities” (Kuhn & Dean, 2004, p.270). This might take attention of the learners on the focus of the activity. Kuhn and Dean (2004) proposed that facilitating a communication platform which includes asking questions about the reasons of the actions might help the learners to ask these kinds of questions to themselves. According to them, metacognitive functions divided into two; procedural and declarative. Procedural metacognitive functions arouses the awareness of the individual’s own thinking while declarative put emphasis on individual’s extensive apprehending of thinking in general (Kuhn & Dean, 2004). Furthermore, Flavell (1978) indicated the importance of metacognitive knowledge as “increasing the quantity and quality of children’s metacognitive knowledge and monitoring skills through systematic training may be feasible as well as desirable” (p.910 cited in Flawell, 1979). This literature supported the view that monitoring the learners and guiding them about their thinking processes by asking questions would help them to develop awareness about their thinking strategies.

Many of the novice participants did not declare a general strategy before starting their CMs; this might be a potential reason of the missing points and the poor quality of their maps. In order to use CMs more effectively, CMs' potential as a metacognitive tool for science education and metacognition support during this process must be emphasized. According to Davidson, Deuser and Steinberg (1994) metacognition supports the learners' ability to identify the problem, comprehend it and accomplish a solution. They presented some of the metacognitive processes that could be used in problem solving process as: "1) identifying and defining problem, 2) mentally representing problem, 3) planning how to proceed and 4) evaluating what you know about your performance" (Davidson, Deuser & Steinberg, 1994, p.208). Guiding the learner by these processes could help them to construct a better image of a deliberate map in his/her mind and start with more planned and structured way. The reason for the higher quality of CMs produced by expert participants was not only due to their vanter grasp of knowledge but also their organized knowledge and strategy. This might be a clue for the instructors to guide them throughout the process and use metacognitive support. The importance of guidance and appropriate instruction were also emphasized by Sternberg and Grigerenko (2003) as the followings: without appropriate guidance or support provided by the instructor or coach, it is not possible to advance the poor performers to higher levels.

Furthermore, according to novices, the easiest steps during CM development process were *naming the concept* step, *branching* and *constructing a relation* steps. They acknowledged that concepts were already in their mind so that it was easier than the other steps. This might be the effect of rote learning as they experienced up to that time. Most of the students had experienced the Matter topic since high school and the strategy in that time mostly on memorizing the information instead of showing the relation between the prior information. On the other hand constructing a relation among two concepts requires information processing, grasping a new knowledge while connecting with the prior one. This might be the reason why participants' considered the process to be harder than the other steps during CM development.

Summary of the section:

- As a general strategy, both novices and experts embraced a *deductive strategy* which is a top-down strategy during CM development. They followed a way which starts from general problem and get deeper into small parts of this general problem step by step. On the other hand, at the initial stages most of the novices did not declare a deliberate strategy but during the process it was revealed that they followed a deductive strategy.
- Experts and novices differed in branch construction patterns; novices followed a synchronized (mirror image) pattern while experts preferred to complete a branch instead of filling every branch.
- Both experts and novices filling the information on map in an order, and following a deductive manner
- The data proved that expert and novice participants used hierarchical maps rather than spider maps.

5.3 Progress Pattern (RQ 1 and RQ 2)

RQ1: Do novices and experts use specific strategies during the concept map development process? /RQ2: How does the concept map development processes differ within novices and experts?

In order to determine whether there were recognizable patterns among participants in terms of their progress during CM development process, 4 periods during their progress were examined. The analysis showed that there was a recognizable pattern among experts and novices in terms of the frequency of determined acts in specific period. Particularly, subject matter affected the frequency of the number of movements (e.g. constructing a concept, link, revision, arrangement, and cross-link and other acts actualized during CM formation process) in different periods. For the Cell topic, the highest total number of movements for both novices and experts were the final period. They differed in late-mid period according their total number of movements. On the other hand, in the Matter topic, experts and novices differed almost in every period. Specifically, experts' total number of movements in the early-mid and final periods was higher than novices.

Additionally, independent from the subject matter, the highest number of movements (observed acts during CM development process) was the final period for both experts and novices. The increase in the total number of movements towards to the final stage could be related with participants' constructing fewer concepts and their efforts on checking errors or revising their maps. It was observed that experts had done more controlling and checking in their maps than the novices in every period but specifically in the final period. Experts tended to construct more cross-links than novices but the attempts of novices increased their total spent time in the crosslink act. This might be related to the difficult nature of constructing cross-links for novices. In terms of reasoning act, it was observed that experts had a higher frequency in the first period than the novices, although the total time spent for this act in the third and last periods showed a similar pattern. This might be related with the experts and novices different knowledge organization during problem solving. As Goldstein (2005) expressed that experts were slower thinker they preferred to comprehend the problem instead of attempting to solve it. This might be the reason for the increase in experts' FD in the first period than the novices. Moreover, the knowledge organization of experts differs from novices; novices classify the problems in terms of their similarities of the objects whereas experts tend to classify the problems by considering the general principles (Goldstein, 2005). In terms of the time spent on task, experts are slower than the novices as they focused on comprehending the problem instead of attempting to find a solution. Although experts seems to spent much more time in problem solving process than the novices, this strategy yields with more effective results (Goldstein, 2005).

Summary of the section:

- Expert and novice participants differentiated in definite acts (controlling and checking, cross-link, and reasoning) during the progression of the map. Their frequency of repeating these acts differed in different periods of the CM development process.

5.4 Eye Movement Pattern (RQ 2.1)

RQ 2.1: Are there differences between novice and expert participants in terms of their eye behavior (e.g. fixation count, visit duration, fixation duration)?

Eye behavior analysis showed that novices' FD periods and VD periods were shorter for both topics than experts According to Goldstein (2005); during the problem solving process experts are slower than novices since they are focusing on comprehending the problem instead of trying to solve it. However, this strategy caused better results, although they spent much more time they yield with better results (Goldstein, 2005). On the other hand, it was found that novices had higher FC than experts in both subject matters. According to Schau and Mattern (1997) "map generation imposes a high level of cognitive demand, both spatial-visual and verbal, on the student. Demand is higher when the assessment task requires students to create an entire map including the concepts" (p.173). The increase in FC is considered as a possible indicator of cognitive process or an interest to that area in many disciplines (Holmqvist, Nystrom, Andersson, Dewhurst, Jarodzka & Weijer, 2011; Doherty, O'Brien & Carl, 2009).

In addition, there were differences between novices and experts in terms of FD periods for three selected acts (cross-link, controlling and checking and reasoning). Especially in crosslink act, experts had spent dramatically high periods than the novices for both subjects. In crosslink act, for the Cell topic experts had spent more time for controlling checking than novices. On the other hand, in the Matter topic their periods were closer to each other. This difference could be related with the one experts' lengthy CM development process than the other experts. For reasoning act, it was seen that experts' FD was higher in both subjects than the novices. As the eye movement metrics showed that experts and novices had a different eye behavior pattern for entire process and within the selected acts. This might be related with the difference in their knowledge organization and routines that they embraced. Particularly, the difference between cross-link actions could be related with the adversity of constructing cross-link since it requires bringing different information in different branches together. Experts' difference might be related with their extended experience in the field and they have accustomed to connect information which eases the process for them.

Moreober, the difference between novices and experts in their general controlling and checking act was realized with the help of eye movement analysis. It was observed that experts tended to control their maps more than the novices, and that brought fewer misconceptions than novices. While determining critical suggestions for novices, this could be a basis to control their maps frequently in every period of the map (beginning, early-mid, late-mid and final). Experts' extended knowledge and experience could also be a reason for fewer misconceptions observed in CMs.

Summary of the section:

- Eye movement pattern showed that experts evaluated their maps more than novices in both subjects. In addition, in reasoning act, experts spent more time in both subjects than novices. Furthermore, experts' number of cross-links was higher than novices for both in the Matter and Cell topics.
- Novices VD periods were less than experts. On the other hand, novices had higher FC numbers than experts.

5.5 Content Richness (RQ 2.2)

RQ 2.2: Are there any differences among experts' and novices' CMs in terms of content richness?

The results showed that experts' CMs were more qualified than the novices' independent to the subject matter. Their all quality measures (the number of concepts, links, cross-links and examples) scores were higher in experts. In general most of the novices constructed less crosslink and examples than the experts; this might be a reason not to observe a significant difference among the novices. The quality of the CMs is also related with the strategy of the participants directly. The detailed analysis of the CMs showed that the novice participants do not include only pure novices. Some of the participants' CM quality and the scores were relatively high. This is a result of the individual differences among participants but might be related with the level of knowledge on the subject of the novice participant. They tended to use different concepts, use more crosslink than the others and more focused on the relation words. According to the retrospective review data, these participants showed a similarity to the expert participants in terms of the organization and construction of map. They declared that they had a picture in their mind and tried to adhere to that picture most of the time which was an observed expert behavior. In addition, like experts they had a tendency to place the concepts consciously while thinking the next step. In order to determine this process in detail and the potential reasons for these grouping between the participants' future studies could be investigated.

Summary of the section:

- In terms of the content richness was taken into consideration, it was observed that experts' CMs were more qualified than novices according to the all quality measures (number of concepts, links, cross-links and examples).

5.6 Other Factors Affect the Concept Map Development Process (RQ3)

RQ3: What are the factors that affect concept map construction process?

The factors that affect the CM development process were determined as subject selection, tool familiarity and language effect. Being familiar to the subject matter eases and shortened the process. In addition, feeling confident on subject matter decreases mistakes. The suitability of the subject for branching was other mentioned factor that affects the process. Furthermore, they stated that although they did not develop a CM in Turkish they have encountered Turkish CMs. They expressed that they preferred to use CMs in English because of the incompatibility of CMs to Turkish language. This view might be related with taking all the courses in English in their university as a result they have accustomed to develop CMs in English. Their lack of experience in Turkish CM development might also affect their preferences. Experts also shared this view; the grammar structure of Turkish language was not suitable for CM development. The verb position was different in Turkish than English.

In order check the reliability of the method used in this study, the general pattern, eye behavior pattern and content richness issues were compared by using two different topics from science. The participants' two CMs were compared whether participants followed different CM development patterns when the topic was changed. It was observed that participants' eye behavior patterns in specific acts, the quality of their maps and the time spent on completing their maps were differed. There were both similarities and differences in participants' eye behaviors during CM development for two topics. It was found that there are statistical differences between participants' FD values among their two CMs in the determined acts. Participants' FD values differed in two different topics. One possible reason for this difference is the participants' varying confidence levels for these different concepts. It is possible that the participants' confidence in the Matter topic increased their control and check, arrange or reasoning acts on the map more than the Cell topic. These results should be considered cautiously as there are limited number of participants (N=15) and the data were analyzed using non-parametric tests. Further research with a higher number of participants and with parametric tests would be useful.

The quality measures also affected the associated acts (constructing a blank concept, writing into a concept and constructing a link) directly. The increase in the constructing a blank concept and writing into a concept directly increased the number of concepts quality measures. Likewise, the increase in constructing a link act caused an increase in the number of links the differences in other acts might be related with the nature of the subject. Although the quality of the maps differed, the general pattern was not changed within the participants' maps in two different topics (Biology and Chemistry). This might be related with the participants' aptitude to that topic and feeling more confident on that topic than the other.The general pattern among participants in two different topics was not changed. They (N=15) all preferred to follow deductive strategy during their mapping process and used hierarchical maps.

The other mentioned factor that affects CM development process was tool familiarity. It was found that although they confirmed that CMap Tool was easier to use than developing CM with paper and pencil, they had problems with tool familiarity. Another frequently mentioned factor that might affect the process was appropriate organization of the content. According to them, limited vocabulary also affected the process, since it causes repetitions in linking words.

Summary of the section:

- Subject matter affected the process directly, since being familiar to the subject eases the process and shortened the time spent on CM development. While determining subjects for CMs, the suitability of the subjects for branching must be taken into consideration.
- Tool familiarity is another issue that affects the CM development process. It is necessary to enable participants to be accustomed to the tool.

- The language structure also affects the process. Turkish language could be problematic for CM development because of its linguistic structure.

5.7 Conclusion

In the literature review, various studies have investigated the effectiveness of CM, in education. The majority of these studies pointed out the practical use of CM's for instructors where it's potential as an assessment tool and the role in concept mapping is addressed. The role of expertise during the concept mapping and potential usages of expert maps are also well known issues among researchers. Exploring the cognitive process and the relation of prior knowledge is also one of the aspects examined. Although these issues were well explored for a long time, this study attempted to combine these perspectives under the same umbrella by aiding the process with an eye behavior analysis.

Exploring the CM development process revealed significant findings. As a general strategy during CM development, both experts and novices followed a deductive thinking pattern, which includes starting with a general concept at the first step and afterwards continuing with constructing sub concepts and links while keeping the relation between the main concept in mind. It was also observed that most of the novices did not declare a deliberate strategy at the initial stages of CM development instead they preferred to develop the map by filling the information which came to their mind first. However, the eye behavior pattern analysis and verbal protocol showed that without being aware of it, novices embraced and followed a specific (deductive) strategy during CM development process. Although, experts did not declare a specific strategy on their CMs, they expressed the existence of plans on their CM development process.

In terms of filling in the information on the map, it was observed that both experts and novices tended to write the linking word and then move on to the next concept, which might be related with the information order in mind. Most of the participants preferred to use hierarchical structure which might be associated with deductive thinking and the appropriateness of hierarchical maps to the subject matter nature. Although the observed patterns among novices and experts showed similarities according to their general strategy, the preferences on CM type and order of filling in information, it was found that they differed in branch construction and progress patterns. Novices tended to follow a synchronized pattern (mirror image), which includes starting to give an example in one branch and continue with other equivalent branches while experts preferred to complete a branch without writing equivalent information under every equivalent branch.

Moreover, it was observed that novices made many revisions which were related to their diligence to find a better representative word. On the other hand, experts made fewer revisions and most of them were not related to the content, instead their revisions were mostly related with tool adaptation. The problems that occurred during the process were related to the organization of the information on the map, like limited vocabulary and tool adaptation. Experts' problems were mostly tool related, although the tool was easy to use, it requires a time to get adapted.

Eye behavior analysis proved that novices had less FD and spent less time in general than experts which could be related to the hasty attempts to solve the problem instead of taking their time to comprehend it. On the other hand, novices' FC numbers were higher than the experts which could be interpreted as their higher cognitive processes during CM development. Particularly, three main acts were observed to examine the cognitive process; constructing crosslink, controlling and checking and reasoning. The findings showed that experts showed considerably high FD for the constructing crosslink act and their crosslink number was also higher in both subjects than novices.

Content richness analysis showed that experts developed more qualified CMs which were independent to the subject matter, but specifically the differences from novices in which quality measures were explored. The results proved that experts' number of concepts and links were significantly higher than novices. A statistically significant difference for the number of crosslink and examples were not observed. However, in both subjects experts quality measures were considerably higher than novices.

Experts and novices progress pattern analysis revealed that their highest total number of movements in determined periods (beginning, early-mid, late-mid, and final periods) was in the final period. They differed in late-mid period than the other periods in terms of the total number of movements. Additionally, subject matter affected this progress pattern as experts and novices showed different patterns almost in every period in the Matter subject than the Cell subject. It was also examined that experts and novices differed in actualizing specific acts (controlling and checking, cross-link, reasoning and revision). Other potential factors that might affect the CM development process could be listed as being familiar to the subject matter, Cmap Tool familiarity, and the language effect.

5.8 Implications for Practice

The results showed that both experts and novices were aware of the potential of CMs in education. However, most of the teachers still have concerns about how to use CMs effectively during the instruction process. With this study, the critical points during CM development for both novices and experts observed and some practical recommendations have been suggested. The strategies were given under three main categories; before starting the concept mapping, during its development (beginning period and early mid period), and after finishing the CM (final period).

- <u>Recommendations Before Starting the CM (Preliminary Suggestions):</u>
    1. According to Novak and Canas (2008) before starting a CM, it is essential to begin "with a domain of knowledge that is very familiar to the person

constructing the map" (p.10). They emphasized that it is best to identify a specific problem to be solved and construct a focus question which defines the problem. The instructors need to be careful at that point since determining better focus questions lead to better CMs (Novak & Canas, 2008). The importance of planning for a successful problem solver was also mentioned by Gagne (1984) as "the problem solver must employ a plan that allows the choice of the intellectual skills to assure that the goal of the problem statement will be attained" (p.186). Therefore, it is necessary to identify the problem beforehand the CM development by the instructor. Additionally, determining a suitable subject matter is another critical issue, since the results showed that familiarity to subjects eases and shortens the CM development process. The instructor needs to be aware of the prior knowledge of the learner. While determining the subject suitability for branching, the suitability of the subject matter to branching and the prior knowledge of the participants needs to be considered by the instructor.

2. Furthermore, it can be suggested to the learners to embrace a hierarchical structure in CM development. Particularly during instruction for beginners in their initial maps, it is recommended to limit the domain of knowledge. Otherwise, the learners might feel lost in a huge content. Additionally, although hierarchical CMs are effective according to Novak and Canas (2008), the researcher observed that the preference on the type of the CMs might be related to the nature of the subject. For that reason, the hierarchical type of CMs can be used but the instructor must be aware of the suitability of the subject.

3. It must be noted that familiarity towards the concept mapping process is also an important factor. Although CM is a valuable tool for learning, it requires a learning process in itself. The results showed that CM is an effective tool but providing the needed time for learners to be accustomed the process. For that

reason, the instructors must enable practicing opportunities to the learners. Before starting CM development, the learners must be aware of the CM development processes and practice on map development with an instructor. The instructor must explain the aim of the study well as well as the role of the concepts, links and cross-links to the learner.

4. Computer based software is an efficient media compared to paper and pencil when constructing CM. The results showed that both novices and experts preferred to use computer based tools because it enables revising and making arrangement much more easily. However, the instructors must be aware of the potential for problems regarding new software usage, since there will be a need for time for users to get learn a new tool. Practicing similar tools could be a solution for shortening this adaptation process.

5. The incompatibility of the Turkish language is another problem that learners and instructors could be faced with. The results showed that both novices and experts agree on this issue, as they preferred to use English. This might be related with having taught in English in their universities. Moreover, their lack of experience in Turkish CMs might also affect their preferences. Language proficiency is another issue for learners; limited vocabulary might cause repetitions in the CM. The instructor might give instant feedback or enable various linking word examples to the learners to enrich the content of the CM.

6. It was observed that experts preferred to follow an internalized map during CM development process while novices tended to begin CM without a planning process about their acts or having a decision about their strategy beforehand. In order to develop better CMs, planning and mentally representing the problem before starting the map are critical steps. In addition, generating a preliminary map in their mind or on a paper to

determine the basic points could be a solution for preventing the missing points. According to Novak and Canas (2008), CMs always need revisions and even good CMs end with many revisions. For that reason, the instructors need to emphasize the importance of this preparation period as much as the other periods in CM.

7. Additionally, the findings showed that experts spent more time in checking their maps fore errors, while novices are less meticulous. However, evaluating the performance is also an important process to determine misconceptions and increase quality. For that reason, teachers need to consider these steps during CM development and give feedback during the process.

8. Instructors must guide their learners to fill the information in their maps in an order (e.g. writing the concept and then filling the relation word and continue with the other concept word). Embracing a deductive manner while filling the information might help them to construct the visual representation of their knowledge easily. Moreover, during branch construction, the instructor need to guide the learners to complete a branch and continue with the other branch which is a common strategy that experts followed.

9. Moreover, embracing a hierarchical structure is recommended to learners which are suitable to deductive thinking process; as known as, a top-down strategy. Novak and Gowin (1984) also mentiones the similarity of hierarchical CMs and visual representation of the individuals thinking process.

- <u>Recommendations for the process (Beginning and Early-mid periods):</u>
  1. As a general strategy during CM development process, instructors could guide learners to use deductive strategy, starting with a general concept at

the beginning and continue by constructing sub-concepts and links while bearing the relation between the main concepts in mind. This strategy enables the learner to organize the information in a meaningful order and realize the missing points or misconceptions easily. It is essential to emphasize the differences between novices' and experts' knowledge organization habits while guiding them. In the literature, it was noted that novices tended to focus on the shallow details or similarities instead of the general principles (Goldstein, 2005). They must be guided to classify the problem while considering the general principles. Moreover, the instructor needs to give the required guidance and enable learners to practice deductive strategy in their maps to be accustomed. Furthermore, learners need to be guided to comprehend the problem instead of trying to solve it.

2. During the CM development process, particularly in the beginning period it was observed that experts tend to control their maps more than novices. In addition they tend to evaluate and check for errors act in the second and last periods. This behavior might be a clue for the instructors to guide the learners to evaluate their maps frequently throughout the entire process of the map development. Particularly, the early mid (second) and last periods could be a good reference point for instructors to guide the learners to evaluate their maps. These periods could be accepted the critical periods for maturation of the map.

3. Cross-links are key elements to see the learners' understanding on the relations between the sub-domains in CM (Novak & Canas, 2008). According to them, it is essential to help learners to realize that all concepts were related to another. They also recommend avoiding long sentences in boxes (Novak & Canas, 2008). This view is also shared by the researcher and the instructors must coach the learners about checking the cross-link possibilities in their maps while avoiding to use long sentences. The results

showed that although novices tried to construct cross-links in every period many of them were not that successful. Experts preferred to wait until the final period to construct cross-links in their maps. Instead of preferring the earlier periods in CM development, postponing the cross-link construction process to later periods could be helpful for looking at the whole picture. In the earlier periods, CMs are usually not mature enough and require many revisions. For that reason, it is better to prefer the later periods to relate the branches with a suitable cross-link. Additionally, some of the students may attempt to link every concept by using either links or cross-links and this could create a crowded CM. Instead of trying to relate every concept, the instructors must guide learners to identify the most useful cross-links (Novak & Canas, 2008). The observations of the researcher was also parallel with this view, instead of constructing more cross-links or attempting every concept with another, the most useful and prominent cross-links need to be identified. Since learners could be inexperienced about selecting the prominent cross-links, the instructor may guide them to select the most useful cross-links by avoiding a crowded CM view. These points might help instructors to guide learners to practice constructing cross-links in their maps. Instant feedback for their cross-links or online mechanism might be also a solution.

4. The results were parallel to the literature as many of the experts were slow problem solvers because they spent too much time on reasoning on the initial phases to comprehend the problem in a deeper level. The instructors must guide the learners to comprehend the problem better in earlier periods instead of the swift attempts to complete the map.

5. In terms of the revision process, the instructors need to guide the learners to revise their maps frequently until it is matured enough. This revision process need to be supported either by a computer based system or an instructor to

evaluate the missing points and misconceptions of the learners. This might help learners to learn effectively and meaningfully by considering the relations between concepts instead of only memorizing the information.

- Recommendations after completing CM:
  1. After completing the CM or in the final period, the learners must evaluate their maps for whether there are any inaccurate information and missing parts. Evaluating the process and performance is critical to find the missing points and ensuring quality. Furthermore, it is necessary to revise the required parts and re-arrange for providing a better CM. It might be effective to use computer based tools for arranging the map more easily than preferring paper and pencil maps. Furthermore, comparing the expert maps or sharing the peer maps with each other could be other options after completed the maps. These comparisons might enable the learners to check the accuracy of their maps with other peers and evaluate the map for missing points with expert maps.

To sum up, effective CM development process and its steps for Turkish language is still a problematic issue for researchers. As it is mentioned in previous chapters, there are extended studies on CMs however, exploring the process and having clues for the re-structured curriculum is needed. It is aimed to provide a different view for covering the cognitive process while taking the roots of learning in mind and to be a base for other practitioners and educators to use CMs effectively. This study is important in terms of being a contribution to the teachers' knowledge about the learners on the CM development. With the help of the information acquired, instructors could guide the learners at the required time and in an efficient way which might affect the richness of the CMs directly.

This study might also offer practical suggestions for regular classroom setting without using CMs like preferring deductive reasoning and hierarchical (top-down) strategies during the instruction. While determining the strategy, it is essential to give emphasis to the nature of the subject. Following a strategy which suits to the nature of the subject might help the learners to establish an accurate mental model. Using deductive reasoning or hierarchical strategies during the instruction might help the learners to learn the topic unit by unit. Some of the topics may include many subtopics which might cause feeling lost in the topic. These types of strategies might help the learners to follow the information in an order without feeling lost in the big content. In addition, for the instructors it eases the process since these types of strategies require starting with general information and going into deeper by giving details.

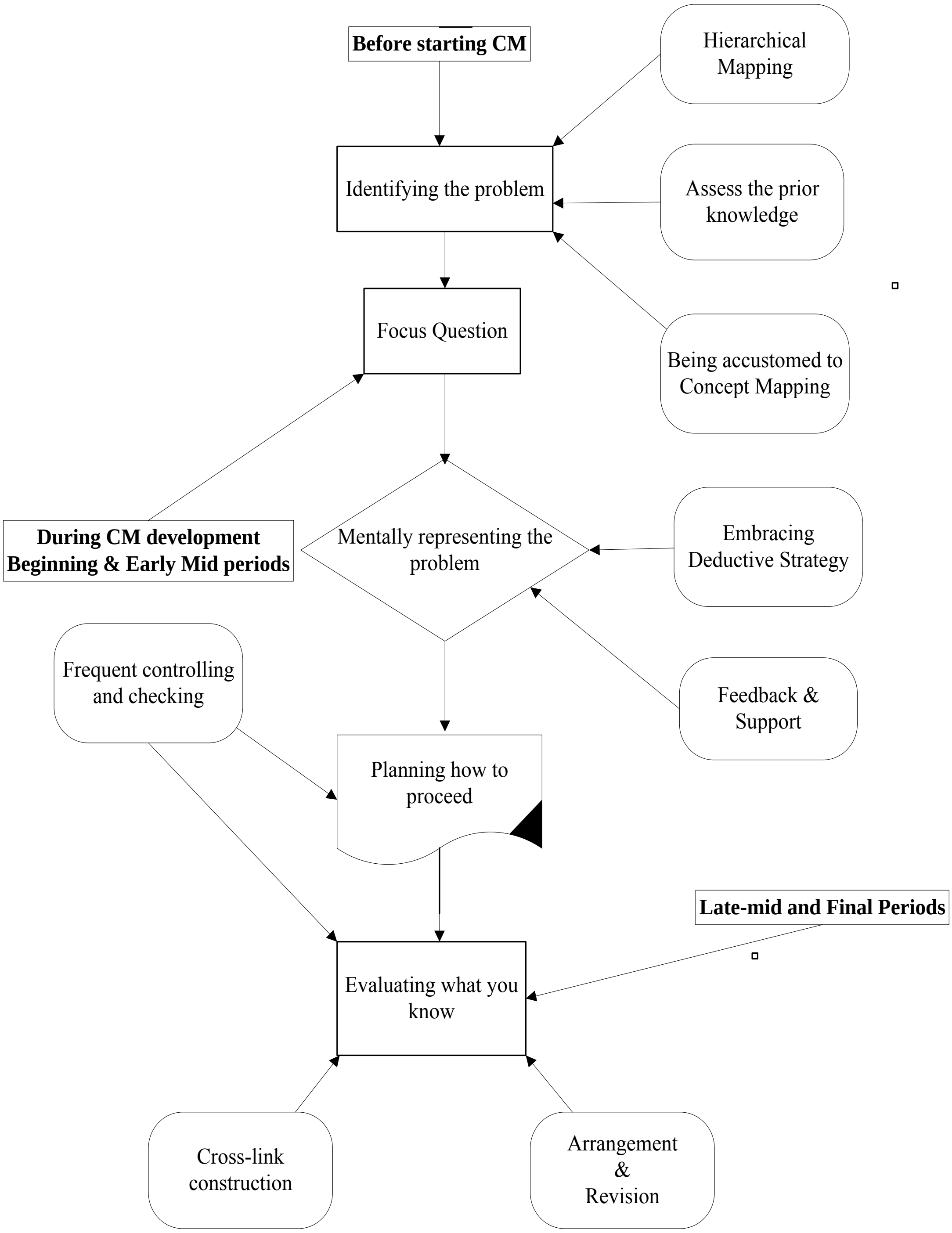


Figure 5.1 Summary of the Implications for Practice

5.9 Limitations and Recommendations for Future Research Studies

Case studies are common among researchers in the field of Instructional Technology because of its unique structure that provides in depth and detailed information about a localized system or combination of systems. However, these types of studies generally have a generalization problem. In this study the main limitation was based on the small sample size and its lack of demographic diversity. However, since nature of eye tracking data was very robust the sample size for the eye tracking method was sufficient to make generalizations. In addition, the participants were consisting of only English language teaching faculty students which is limited to a small population in Turkey. In order to have a diverse perspective and observe the potential pattern among them, it is required to collect data from different universities and different faculties by increasing the sample size and diversity.

Besides, developing a CM from the very beginning requires a lengthy data collection process. Many participants were exhausted because of this extended CM development process. Particularly, some of the participants attended the study twice and this lengthy data collection process frustrated them drastically. Hence, some of them were not willing to participate to the eye tracking session, although they filled the open-ended questionnaire, and the prior knowledge test. Thereupon, the attendance rate was lower than the researcher expected. In addition, in total 44 participants were attended to the study, but 9 of them were excluded because of the poor data quality of the recordings. Their eye movements were not sufficient to be considered in the analysis process. This might be related with the long duration of data collection process which is a distracting process and participants' tendency to think without looking at the screen during CM development process. Furthermore, the narrow number of the participants and the imparity among the groups prevented the inferential statistics which could statistically reveal the difference between expert and novice participants.

For future studies, it is recommended that a diverse group of participants would be selected and data collected through a long period of time to prevent the data loss. Additionally, an in-depth longitudinal study shall be repeated with another group of participant to determine the process of becoming an expert. This longitudinal study will enable researcher to observe the progress more precisely and examine the maturation process. According to Ericsson et al. (2006), to assess the proficiency level academic qualifications could be measured (for example graduate versus undergraduate students, the years that the expert spent on specific domain) or using performance tests. In this study, the number of participants limited the researcher to categorize the group according to different expertise levels. In order to determine the possible categorizations according to their expertise level, a wider group which consists of adequate number of experts and graduate students would be selected.

In addition to the generalization issue related with the sample size, there were other limitations in this study. Since the main data source was human beings, the researcher was dependent on the participants' discourse in disclosing the process that makes inferences about their behaviors. The researcher assumed that the participants answered the questions and verbalized the feelings honestly, otherwise it might be considered as a limitation for the study.

The tendency to prefer hierarchical map style rather than spider map could be another further study issue. Many of the instructors in higher education in Turkey embraced the Novak style CMs that suggests hierarchical mapping. This might affect the preferences of the novices since they might take their instructors as a role-model. As a result of this tendency among instructors as preferring hierarchical type CMs might effect the CM type selection. For further studies, different types of topics or subjects could be selected which suits to spider mapping type to explore the effect of the instructors' selection on novices' preferences. Moreover, this study might be replicated with different subject matters to observe whether there are differences among science and social science related subjects according to CM development processes. In addition, it might be possible to investigate the effect of the appropriateness of the CM type to the content and the previously learned style from their instructors on their preferences.

Moreover, with the waves of Constructivist Movement and its consequences perspectives of the educators and learners changed significantly. In Turkey, the curriculum was re-structured towards this constructivist approach in recent years and CMs were included in this new curriculum. However, constructivist approach brought an assessment problem; CMs could be a solution for teachers to evaluate students' existing knowledge and whether they could get connected with the new information.

Although this study has practical implications for CM usage in education, its value was limited to English language teaching schools and faculties. For that reason, in order to explore the effectiveness of CMs for Turkish language teaching, this study would be repeated with a new group of participants in Turkish. Eye tracking data would provide the difference between participants' CMs in English and in Turkish. This would be helpful for researcher to determine the effective usage of Turkish CMs, or effective representation possibilities of CMs in Turkish. Moreover, with the aid of comparison studies researchers might be able to develop different tools like CMs or to try to make arrangements for effective adaption of CMs to the Turkish language. This is a problematic issue which many science teachers faced within in Turkey that is not easily handled.

Another finding on preferring CMs to use in education was its potential as a supporting tool in many stages of instruction. The critical points during the development process and the general strategies were also revealed. These points and the embraced strategies might help both the researchers and instructors to aid learners while defining a framework for CM development process. Although the language structure is different in Turkish other than English, many of them still consider CMs as applicable to their future teaching life, as it was supported in the literature with some strategies. For further studies, exploring the relation and physical distance between main concept and sub-concepts would be explored. By examining this arrangement, it would be possible to investigate the possible patterns among experts and novices while locating the main concept and sub-concepts while emphasizing the distance. This might help the researchers to develop different analysis mechanisms which give emphasize the distance to the main concept and order of sub-concepts.

This study attempted to explore the apparent pattern among expert and novice participants during their CM development process. Since CMs are valuable tools for enabling the visualization the information in mind meaningfully without a need of memorizing the information. In order to explore the effective usage possibilities of CMs in education, future studies might be repeated by using CMs and instant feedback mechanism. This might help to reduce the misconceptions and facilitate constructing a bridge between the newly learned and existing information.

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APPENDIX A

INFORMED CONSENT (TURKISH)

Bu çalışma, ODTÜ Bilgisayar ve Öğretim Teknolojileri Eğitimi Bölümünde Doç. Dr Kürşat Çağıltay danışmanlığında Araştırma Görevlisi Berrin Doğusoy tarafından doktora tezi kapsamında uzman ve deneyimsiz kullanıcıların kavram haritası oluşturma süreçlerini "ortaya koyabilmek" amacıyla yürütülmektedir. Çalışmanın amacı, uzman ve deneyimsiz katılımcıların kavram haritası oluşturma süreçlerini bilişsel gözden geçirme yoluyla analiz ederek ortaya çıkarabilmektir. Aynı zamanda, çalışma kapsamında katılımcıların oluşturdukları kavram haritalarına yönelik yorumlayıcı bir deneme yazmaları ve süreci anlatmaları istenecektir. Katılımcıların bu süreci anlatabilmeleri için daha önceden hazırlanmış sorular verilecek bunların yanıtlanması istenecektir. Yapılacak çalışma Methods of Science & Mathematics Teaching (ELE 336) dersi kapsamında 55 öğrenciye ve uygulanacak İnsan Bilgisayar Etkileşim laboratuarında 5 hafta sürecektir. Bunun yanı sıra çalışmaya 6 uzman katılarak aynı konu üzerine bir kavram haritası oluşturacak ve bununla ilgili yorumlayıcı deneme sorularına yanıt vereceklerdir. Cevaplarınız ve bilgileriniz tamamıyla gizli tutulacak ve sadece araştırmacılar tarafından değerlendirilecektir, elde edilen bilgiler doktora tezi kapsamında ve bilimsel yayımlarda kullanılacaktır. Uygulama öncesi katılımcılara verilecek bilgi testleri, genel olarak seçilen konuya yönelik bilgi birikimlerini ortaya koyma amaçlı hücre konusu için 14 soru ve Madde konusu için 25 sorudan oluşmaktadır. Bunun yanı sıra çalışma öncesi katılımcılara verilecek açık uçlu sorular yardımı ile kavram haritalarına yönelik geçmiş bilgileri ve bu konuya yönelik görüşlerinin alınması amaçlanmaktadır. Bunun ardından katılımcılara oluşturacakları kavram haritasına yönelik olarak bilgilerini tekrar edebilmeleri için önceden hazırlanmış olan Biyoloji-Hücre konusuna ait bir çalışma kağıdı verilecektir. Ardından göz izleme cihazını kullanarak kavram haritalarını oluşturmaları beklenecektir. Katılımcıların kavram haritalarını oluşturmalarının ardından bu haritayı oluşturma süreçlerini özetleyen yorumlayıcı deneme sorularını yanıtlamaları beklenecektir. Uygulama sırasında sorulardan ya da herhangi başka bir nedenden ötürü kendinizi rahatsız hissederseniz cevaplama işini yarıda bırakıp çıkmakta serbestsiniz. Böyle bir durumda uygulamayı yürüten kişiye, uygulamayı ya da soruları tamamlamadığınızı söylemek yeterli olacaktır. Uygulama sonunda, bu çalışmayla ilgili sorularınız cevaplanacaktır. Bu çalışmaya katıldığınız için şimdiden teşekkür ederim. Çalışma hakkında daha fazla bilgi almak için Bilgisayar ve Öğretim Teknolojileri Eğitimi Bölümü araştırma görevlisi Berrin Doğusoy (Oda: C102; Tel: 210 7525; E-posta: bdogusoy@metu.edu.tr) ile iletişim kurabilirsiniz.

Bu çalışmaya tamamen gönüllü olarak katılıyorum ve istediğim zaman yarıda kesip çıkabileceğimi biliyorum. Verdiğim bilgilerin bilimsel amaçlıyayımlardakullanılmasını kabul ediyorum. (Formu doldurup imzaladıktan sonra uygulayıcıya geri veriniz).

İsim Soyad	Tarih	İmza	Alınan Ders
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APPENDIX B

DEBRIEFING FORM (TURKISH)

Bu çalışma, ODTÜ Bilgisayar ve Öğretim Teknolojileri Eğitimi Bölümünde Doç. Dr Kürşat Çağıltay danışmanlığında Araştırma Görevlisi Berrin Doğusoy tarafından doktora tezi kapsamında Uzman ve Deneyimsiz Kullanıcıların Kavram Haritası Oluşturma Süreçlerini "ortaya koyabilmek" amacıyla yürütülmektedir. Çalışmanın amacı, uzman ve deneyimsiz katılımcıların kavram haritası oluşturma süreçlerini bilişsel gözden geçirme yoluyla analiz ederek ortaya çıkarabilmektir. Aynı zamanda, çalışma kapsamında katılımcıların oluşturdukları kavram haritalarına yönelik yorumlayıcı bir deneme yazmaları ve süreci anlatmaları istenecektir. Katılımcıların bu süreci anlatabilmeleri için daha önceden hazırlanmış sorular verilecek bunların yanıtlanması istenecektir. Yapılacak çalışma Methods of Science and Mathematics Teaching (ELE 336) dersi kapsamında 55 öğrenciye ve uygulanacak İnsan Bilgisayar Etkileşim laboratuarında 5 hafta sürecektir. Bunun yanı sıra çalışmaya 6 uzman katılarak aynı konu üzerine bir kavram haritası oluşturacak ve bununla ilgili yorumlayıcı deneme sorularına yanıt vereceklerdir. Cevaplarınız ve bilgileriniz tamamıyla gizli tutulacak ve sadece araştırmacılar tarafından değerlendirilecektir, elde edilen bilgiler doktora tezi kapsamında ve bilimsel yayımlarda kullanılacaktır.

Uygulama öncesi katılımcılara verilecek bilgi testleri, genel olarak seçilen konuya yönelik bilgi birikimlerini ortaya koyma amaçlı hücre konusu için 14 soru ve Madde konusu için 25 sorudan oluşmaktadır. Bunun yanı sıra çalışma öncesi katılımcılara verilecek açık uçlu sorular yardımı ile kavram haritalarına yönelik geçmiş bilgileri ve bu konuya yönelik görüşlerinin alınması amaçlanmaktadır. Bunun ardından katılımcılara oluşturacakları kavram haritasına yönelik olarak bilgilerini tekrar edebilmeleri için önceden hazırlanmış olan Biyoloji-Hücre konusuna ait bir çalışma kağıdı verilecektir.Ardından göz izleme cihazını kullanarak kavram haritalarını oluşturmaları beklenecektir. Katılımcıların kavram haritalarını oluşturmalarının ardından bu haritayı oluşturma süreçlerini özetleyen yorumlayıcı deneme sorularını yanıtlamaları beklenecektir. Ancak, uygulama sırasında sorulardan ya da herhangi başka bir nedenden ötürü kendinizi rahatsız hissederseniz cevaplama işini yarıda bırakıp çıkmakta serbestsiniz. Böyle bir durumda uygulamayı yürüten kişiye, uygulamayı ya da soruları tamamlamadığınızı söylemek yeterli olacaktır. Uygulama sonunda, bu çalışmayla ilgili sorularınız cevaplanacaktır. Bu çalışmaya katıldığınız için şimdiden teşekkür ederim.

Bu çalışma kapsamında göz izleme hareketlerini kullanarak kişilerin kavram haritası oluşturma süreçlerine yönelik bilgi edinilmesi amaçlanmaktadır. Kişilerin bu süreç içinde hangi noktalara daha fazla odaklandıkları, süreç içerisinde zorlandıkları noktaların tespit edilmesi ve kavram haritası oluşturma süreçlerinin ayrıntılı olarak ortaya konulması amaçlanmaktadır. Kişilerin göz hareketlerinin bilişsel süreçlerine yönelik bilgi verebildiğine yönelik literatürde yapılan çalışmalar bulunmasına rağmen bu sürecin daha ayrıntılı ve doğru bir şekilde ortaya konulabilmesi için, yorumlayıcı deneme soruları yardımı ile katılımcıların kendi yorumları alınacaktır. Bunun yanı sıra, katılımcılardan cevaplandırmaları istenen yorumlayıcı deneme soruları yardımı ile süreç içerisindeki hareketlerin kişilerden alınan gerçek bilgiler yardımı ile sürecin yorumlanması ve doğrulanması sağlanacaktır. Bu çalışmadan alınacak ilk verilerin Mayıs 2011 sonunda elde edilmesi amaçlanmaktadır. Elde edilen bilgiler sadece bilimsel araştırma ve yazılarda kullanılacaktır. Çalışma hakkında daha fazla bilgi almak için Bilgisayar ve Öğretim Teknolojileri Eğitimi Bölümü araştırma görevlisi Berrin Doğusoy (Oda: C102; Tel: 210 7526; E-posta: bdogusoy@metu.edu.tr) ile iletişim kurabilirsiniz.

APPENDIX C

CONCEPT MAP INVENTORY QUESTIONS (TURKISH)

Ad - Soyad :
Sınıf :
Yaş:

Betimleyici Sorular

1. Daha önce kavram haritası oluşturdunuz mu? Kaç tane?

____

____

2. Hangi türlerde kavram haritaları hazırladınız?

____

____

3. Genel olarak hangi konularda kavram haritaları hazırladınız?

____

____

4. Sizce kavram haritalarının kullanılmasına daha uygun olan alanlar var mı? Bu alanlar sizce kavram haritası kullanımına neden daha uygun?

____

____

5. Kavram haritalarını yararlı buluyor musunuz? Neden ?

____

____

6. Kavram haritası oluştururken nelere dikkat edersiniz?

____

____

7. Kavram haritası oluştururken izlediğiniz belirli bir strateji var mı? Varsa genelde nasıl bir strateji izliyorsunuz?

____

____

8. Gelecekteki öğretmenlik yaşantınızda kavram haritalarını kullanmayı düşünür müsünüz? Neden?

____

____

9. Gelecekte kavram haritası kullanmayı düşünüyorsanız, çoğunlukla hangi tür kavram haritaları kullanmayı tercih edersiniz? Neden?

____

____

Katıldığınız için teşekkür ederim.

APPENDIX D

INTERPRETATIVE ESSAY QUESTIONS (TURKISH)

Ad-Soyad:
Yaş:

Yorumlayıcı Deneme Soruları

1. Kavram haritanızı oluşturmaya nasıl başladınız?

____

____

____

2. Kavramları ve ilişkileri yerleştirmeden önce neler düşündünüz?

____

____

____

3. Kavram haritanızı oluştururken isimlendirme (isim verme) sürecinde neler yaptınız? Bazı kavramları ve ilişkileri sildiniz mi? Tekrar yazdığınız kavramlar oldu mu? Neden?

____

____

____

4. Kavram haritanızı oluştururken herhangi bir strateji izlediniz mi? Üst kavramdan alt kavrama ya da alt kavramlardan üst kavrama doğru? Bu stratejiyi seçmenizde etkili olan sebepler nelerdi?

____

____

____

5. Kavram haritanızda hangi bölümleri daha kolay oluşturdunuz? (İsimlendirme, Dallandırma, ilişkileri kurma) Neden?

____

____

____

6. Kavram haritanızı oluşturma sürecinizde herhangi bir sorunla karşılaştınız mı? Karşılaştıysanız bu sorunları nasıl çözdünüz?

____

____

____

7. Seçilen konu kavram haritanızı oluşturma sürecini etkiledi mi? Nasıl?

____

____

____

8. Kavram haritanızı oluşturmanız aşamasında size verilen çalışma kağıdı yararlı oldu mu? Hangi açılardan?

____

____

____

APPENDIX E

HANDOUT FOR CELL (ENGLISH)

The cell is the structural and functional unit of all living organisms, and is sometimes called the "building block of life." The cell theory, first developed in 1839 by Matthias Jakob Schleiden and Theodor Schwann, states that all organisms are composed of one or more cells. All cells come from preexisting cells. Vital functions of an organism occur within cells, and all cells contain the hereditary information necessary for regulating cell functions and for transmitting information to the next generation of cells. Cells show two organizational patterns: Prokaryotic and Eukaryotic

Prokaryotic cell is the organization is characteristic of the domain of Bacteria and Archaea. Organisms in these domains are called prokaryotes. Their cells do not have membrane-enclosed internal compartments. All prokaryotic cells share certain features;

- The plasma membrane encloses the cell, regulating the traffic of materials into and out of the cell and separated it from its environment.
- A region called the nucleoid contains the hereditary material (DNA) of the cell.

The rest of the material enclosed in the plasma membrane is called the cytoplasm. Cytoplasm is composed of two parts: the liquid cytosol and insoluble suspended particles including ribosomes.

- The cytosol consists mostly of water that contains dissolved ions, small molecules and soluble macromolecules such as proteins.
- Ribosomes are granules about 25nm in diameter that are sites of protein synthesis.

Eukaryotic cell organization is found in the domain Eukaryo, which includes the protists, plants, fungi and animals. The genetic material (DNA) of eukaryotic cells is contained in a special membrane-enclosed compartment called the nucleus. Eukaryotic cells also contain other membrane-enclosed compartments in which specific chemical reactions take place. Organisms with this type of cell are known as eukaryotes. Animals and plants, fungi and protoists have cells that are usually larger and structurally more complex than those of the prokartoses. Eukaryotic cells generally have dimensions ten times greater than those of prokaryotes.

- An internal cytoskeleton that maintains cell shape and moves materials.
- Membranous compartments in the cytoplasm whose interiors are separated from the cytosol by a membrane.

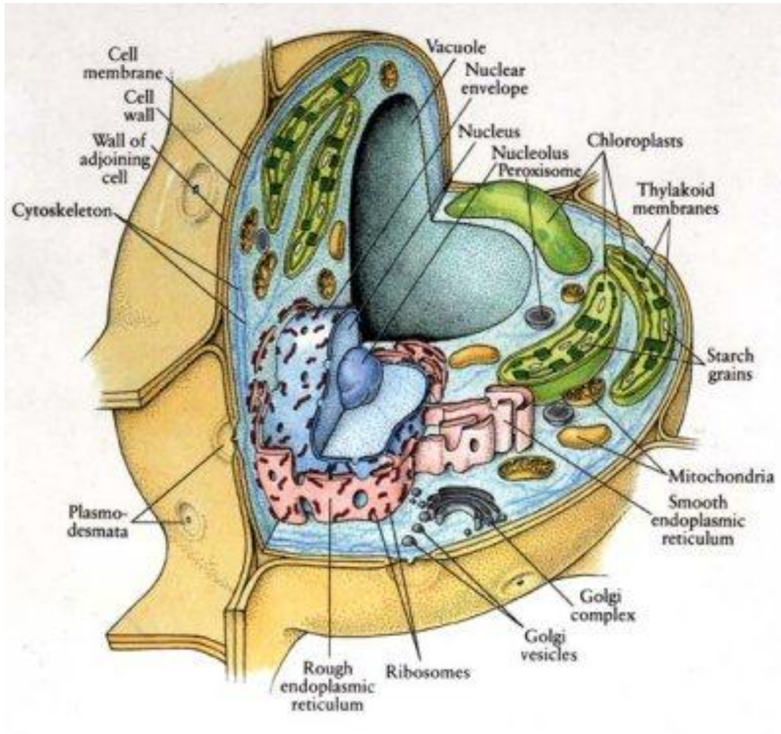


Figure E. 1. Plant Cell

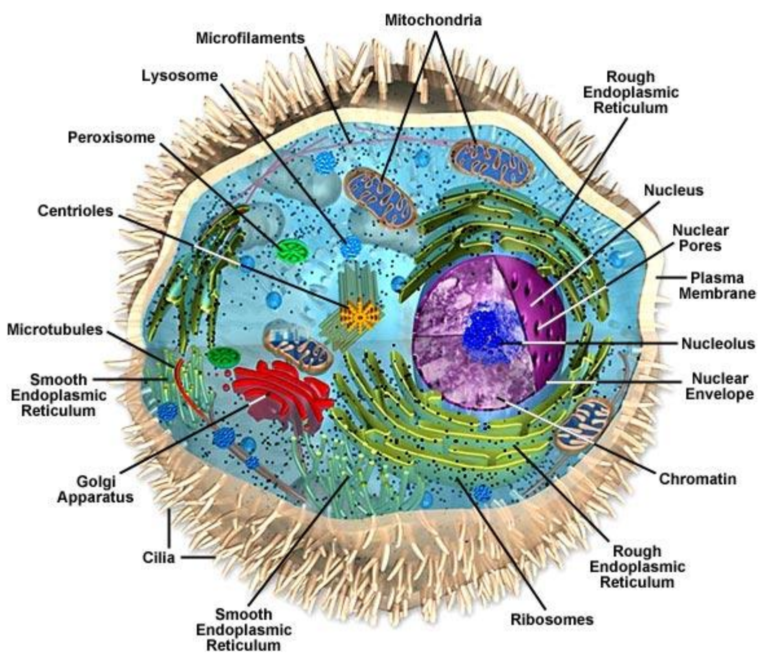


Figure E. 2. Animal Cell

Organelles in Cell

1. Nucleus: the nucleus contains most of the cell's genetic material (DNA). It determines the expression of this material as cell functions and its duplication when the cell reproduces.

2. Mitochondrion: The mitochondrion is a power plant and industrial park, where energy stored in the bonds of carbohydrates is converted to a form more useful to the cell and certain essential biochemical conversions of amino acids and fatty acids occur.

3. Endoplasmic Reticulum (ER) and Golgi apparatus: They make up a compartment where proteins are packaged and sent to appropriate locations in the cell.

4. Ribosome: In both eukaryotic and prokaryotic cells, proteins are synthesized on thousands of ribosomes. Ribosomes are tiny granules found in three places in almost all eukaryotic cells: free in the cytoplasm, attached to the surface of endoplasmic reticulum and inside the mitocondria, where energy is processed and are also found in chroplasts, the photosynthetic organelles of plant cells

5. Lysosome and vaculoe: Lysosome originating in part from Golgi apparatus. Vaculoes are filled with water and soluable substances. Both lysosome and vacuole are cellular digestive systems, where large molecules are hydrolyzed into usable monomers.

6. Cell Wall: The cell wall is found in plant cells and some protests but not in animal cells. It is stiff and gives a rigid shape to the cell.

7. Plasma Membrane: The plasma membrane separates the cell from its environment and regulates traffic of materials into and out of the cell.

8. Plastids: One class of organelles- the plastids- is produced only in plants and certain protists. There are several types of plastids with different functions.

- Chloroplast: Chloroplast contains the green pigment chlorophyll and is the site of photosyhthesis.
- Chromoplast: the red color of a flower or ripe tomato results from the presence of legions of plastids called chromoplasts. Just as chloroplasts are red, orange or yellow depending on the kinds of carotenoid pigments present.

9. Peroxisomes: Small organelles and have a single membrane and granular interior. Peroxisomes are organells within which toxic peroxides are formed as unavoidable side products of chemical reactions.

10. Glyoxysome: Structurally similar organelle, it is found only in plants. Glyoxysomes, which are most prominent in young plants, are the sites where stored lipids are converted into carbohydrates for transport to growing cells.

APPENDIX F

HANDOUT FOR MATTER (ENGLISH)

Modern chemistry emerged in the 18th century, when chemists began to use the balance systematically as a tool in research. Balance measure mass, which is the quantity of matter in a material. Matter is defined as anything that has mass and occupies space. Matter is generally found in one of three states, solid, liquid or gas.

1. Solid; the form of matter characterized by rigidity; a solid is relatively incompressible and has fixed shape.
2. Liquid; the form of matter that is a relatively incompressible fluid; a liquid has a fixed volume but no fixed shape.
3. Gas; the form of matter that is an easily compressible fluid; a given quantity of gas will fit into a container of almost any size and shape.
    - One characteristic property of a gas is its compressibility-its ability to be squeezed into a smaller volume by the application of pressure. Liquids and solids are relatively incompressible. The compressibility of gases was first studied quantitatively by Robert Boyle in 1661. He conducted many experiments and formulated the law mow known by his name. According to Boyle's law, "the volume of a sample of gas at a given temperature varies inversely with the applied pressure". Another law was introduced by Jacques Alexandre Charles in 1787 which is related with the quantitative observations of gases at different temperatures.

Matter may also be classified by its chemical constitution as element, compound or mixture. Materials are either substances or mixtures of substances. Substances are either elements or compounds, which are composed of two or more elements. Mixtures can be separated into substances by physical processes, but compounds can be separated into elements only by chemical reactions.

- Physical change is a change in the form of matter but not in its chemical identity. Changes of physical state are examples of physical changes. The process of dissolving one material in another is a further example of physical change.

- Chemical Change or chemical reaction is a change in which one or kinds of matter are transformed into a new kind of matter or several new kinds of matter. The rusting the iron, during which iron combines with oxygen in air to form a new material called rust, is a chemical change.

Classification of matter

The basic building blocks of matter are called atoms. The structure atom consists of two kinds of particles; a nucleus, the atom's central core, which is positively charged and contains most of the atom's mass, and one or more electrons. Nucleus also includes two particles as proton and neutron. A proton is a nuclear particle having the positive charge equal to that of the electron and a mass more than 1800 times that of the electron. A neutron is a nuclear particle having a mass almost identical to that of the proton but no electric charge. Electron is a very little, negatively charged particle that exists in the region around the atom's positively charged nucleus.

Matter that is composed of a collection of a single type of atom is known as element. The known elements range from common substances, such as carbon, iron and silver to uncommon ones lutetium and thulium. The complete list of elements known as periodic table was constructed by Dmitri Ivanovich Mendeleev. A sample of matter composed of two or more elements is known as compound. A molecule is the smallest entity of a compound having the same proportions of the consistent atoms as does the compound as a whole. Collectively, elements and compounds comprise the types of matter called substances. Mixtures of substances can be classified as homogenous or heterogeneous.

- A heterogeneous mixture is a mixture that consists of physically distinct parts, each with different properties.
- A homogenous mixture also known as solution is a mixture that is uniform in its properties throughout given samples.

APPENDIX G

RETROSPECTIVE REVIEW DEBRIEFING QUESTIONS (TURKISH)

Merhaba,

Ben Berrin Doğusoy, ODTÜ Eğitim Fakültesi, Bilgisayar ve Öğretim Teknolojileri Eğitimi Bölümünde Araştırma Görevlisiyim. Öncelikle, bu bilgilendirme görüşmesini kabul ettiğiniz için teşekkür ederim. Bu çalısmada, öğretmen adaylarının ve alan uzmanlarının kavram haritası oluşturma süreçlerini ayrıntılı bir şekilde ortaya koymayı ve bu süreçlerdeki benzerlikleri ve farklılıkları belirlemeyi amaçlıyorum. Bu konuda olşturmuş olduğunuz kavram haritanızın kayıtlı görüntülerini izleyerek süreci çözümlemek için sizden kendi cümleleriniz yardımıyla ayrıntılı bilgi almak istiyorum. Görüntülerde yapmış olduğunuz tüm hareketleri eş zamanlı izleme şansımız olacak ve ben sizden izlediğimiz hareketlerin sebepleri ve sonuçları üzerine bilgi edinmek istiyorum. Kişisel bilgileriniz ve cevaplarınız kesinlikle gizli tutulacak, sadece bu araştırma için kullanılacak ve araştırma sonunda toplu halde sunulacaktır. Talep edilirse, görüşme kayıtları öğretmen adayları ve araştırmaya katılan alan uzmanları ile paylaşılacak ve onlardan geri bildirim alınacaktır. Araştırma sonuçlandığında size bilgi verilecektir. Bütün bu açıklamalardan sonra verdiğiniz bilgilerin araştırmamda kullanılmasına izin verir misiniz? Şimdi video'yu başlatıyorum ve kavram haritanızı oluşturma süreçleriniz üzerine konuşmaya başlayabiliriz.

1. Siz her iki konuda da kavram haritası hazırladınız? Kavram haritası oluşturma süreçlerini gözönünde bulundurduğunuzda hangi konu sizin için daha kolaydı? Neden?
2. Size fırsat verilseydi kavram haritanızı Turkçe mi İngilizce mi hazırlamayı tercih ederdiniz? Neden?

3. Kavram haritası oluşturma sürecinde kafanızda belirli bir stratejiniz var mıydı? Bu stratejiyi kullanmanızın sebepleri nelerdir?
4. Kavram ve ilişki oluşturma süreçlerinde izlediğiniz bir sıralama var mıdır? Dallandırma yaparken izlediğiniz belirli bir strateji var mıdır?
5. Gelecekteki öğretmenlik yaşantınızda kavram haritalarını kullanmayı düşünür müsünüz?
    a. Dersin hangi aşamasında ve ne amaçla kullanmayı düşünürsünüz?
6. Son olarak CmapTool u kullanma aşamasında hiç zorlandınız mı? Seçme şansı verilseydi elde hazırlamayı mı yoksa bu tool ile hazırlamayı mı tercih ederdiniz? Neden?

Katılımınız ve verdiğiniz yararlı bilgiler için çok teşekkür ederim.

APPENDIX H

CELL CONCEPT TEST (TURKISH)

Sevgili öğrenciler,
Aşağıda hücre konuları ile ilgili 14 adet çoktan seçmeli soru bulunmaktadır. Her sorunun bir doğru yanıtı vardır, doğru olduğunu düşündüğünüz yanıtı lütfen daire içine alınız.

1. Hücre zarı ile ilgili aşağıdakilerden hangisi yanlıştır?
   a) Hücrenin çevresiyle alışveriş yapmasını sağlar.
   b) Hayvan hücresinde bulunmaz.
   c) Çok ince yapılıdır.
   d) Seçici geçirgendir.
2. Mitokondri ile ilgili olarak aşağıdakilerden hangisi doğrudur?
   a) Hücrenin enerji üreten organelidir.
   b) Bir çeşit hücre ağzıdır.
   c) Besinlerin içinde sindirildiği kofuldur.
   d) Hücre bölünmesini yöneten organeldir.
3. I. İçinde bir ya da birkaç çekirdekçik bulunur.
   II. Sitoplazma içinde dağılmış durumdadır.
   III. Hücrenin yönetim merkezidir.
   Yukarıdakilerden hangileri hücre çekirdeği ile ilgili temel özelliklerdendir?
   a) I
   b) II
   c) I,III
   d) I,II,III
4. Sitoplazmasında cok fazla mitokondri bulunan bir hücre için aşağıdaki varsayımlardan hangisi ileri sürülebilir?
   a) Protein sentezi hızlıdır.
   b) Hücre içi sindirim yapmaktadır.
   c) ATP sentezi hızlıdır.
   d) Bölünmeye hazırlanmaktadır.
5. Aşağıdakilerden hangisi hücre zarının en önemli özelliğidir?
   a) Protein bulundurması
   b) Seçici geçirgen olması
   c) Yağ bulundurması
   d) Saydam ve ince olması
6. Aşağıdakilerden hangisi bütün canlı hücrelerde ortak bulunan bir yapı değildir?
   a) Kloroplast

b) Enzim
c) Sitoplazma
d) Hücre zarı

7. Aşağıdaki organel çiftlerinden hangisi hem bitki hem hayvan hücresinde bulunur?
    a) Mitokondri- Sentrozom
    b) Endoplazmik Retikulum- Plastid
    c) Golgi cisimciği- Mitokondri
    d) Hücre zarı- Hücre çeperi
8. Bir hücrede DNA molekülüne hangi organellerde rastlanır?
    a) Mitokondri – Endoplazmik Retikulum
    b) Mitokondri – Kloroplast
    c) Ribozom – Golgi cisimciği
    d) Lizozom – Kloroplast
9. Sentrozom bulunan bir hücrede aşağıdakilerden hangisi <u>bulunmaz</u>?
    a) Golgi cisimciği
    b) Hücre zarı
    c) Ribozom
    d) Plastid
10. Hücre çekirdeğinde aşağıda belirtilen yapılardan hangisi <u>bulunmaz</u>?
    a) Çekirdek zarı
    b) Koful
    c) Çekirdekçik
    d) DNA
11. Aşağıdaki hücre bölümlerinden hangisi cansızdır?
    a) Çekirdek
    b) Sitoplazma
    c) Hücre ceperi
    d) Hücre zarı
12. Aşağıdaki organellerden hangisinin karşısına onunla ilgili bir olay yazılmamıştır?
    a) Endoplazmik Retikulum – Madde iletimi
    b) Lizozom – Protein sentezi
    c) Mitokondri – Oksijen tüketimi
    d) Golgi cisimciği – Salgı paketleme
13. Bir hücrede protein sentezi ile ribozom arasındaki ilişkiye benzer bir ilişki hücre içi sindirim ile aşağıdakilerden hangisi arasında vardır?
    a) Golgi cisimciği
    b) Lizozom
    c) Sentrozom
    d) Endoplazmik Retikulum
14. Tükürük bezine ait hücrelerde aşağıdaki hücresel yapılardan hangisinin sayısı fazladır?
    a) Ribozom
    b) Endoplazmik Retikulum
    c) Lizozom
    d) Golgi cisimciği

Katıldığınız için çok teşekkür ederim.

APPENDIX I

MATTER CONCEPT TEST (TURKISH)

BÖLÜM I) AŞAĞIDAKİ SORULARDA DOĞRU SEÇENEKLERİ YUVARLAK İÇİNE ALINIZ.

1) Asağıdaki varlıklardan hangileri madde değildir?
   I. güneşten dünyamıza ulaşan ışınlar
   II. bisiklet tekerleğindeki hava
   III. yeni doğmuş bebek
   IV. yanmış kibrit çöpü
   V. fön makinesinden çıkan sıcak hava

a) Yalnız I   b) Yalnız II   c) Yalnız III   d) Yalnız V

2) Aşağıdaki varlıklardan hangileri atomlardan yapılmıştır?
   I. güneşten dünyamıza ulaşan ışınlar
   II. musluktan akan su
   III. çürümüş yaprak
   IV. fön makinesinden çıkan sıcak hava
   V. yeni doğmus bebek

a) Yalnız II   b) Yalnız III   c) I,II ve III   d) II,III,IV ve V

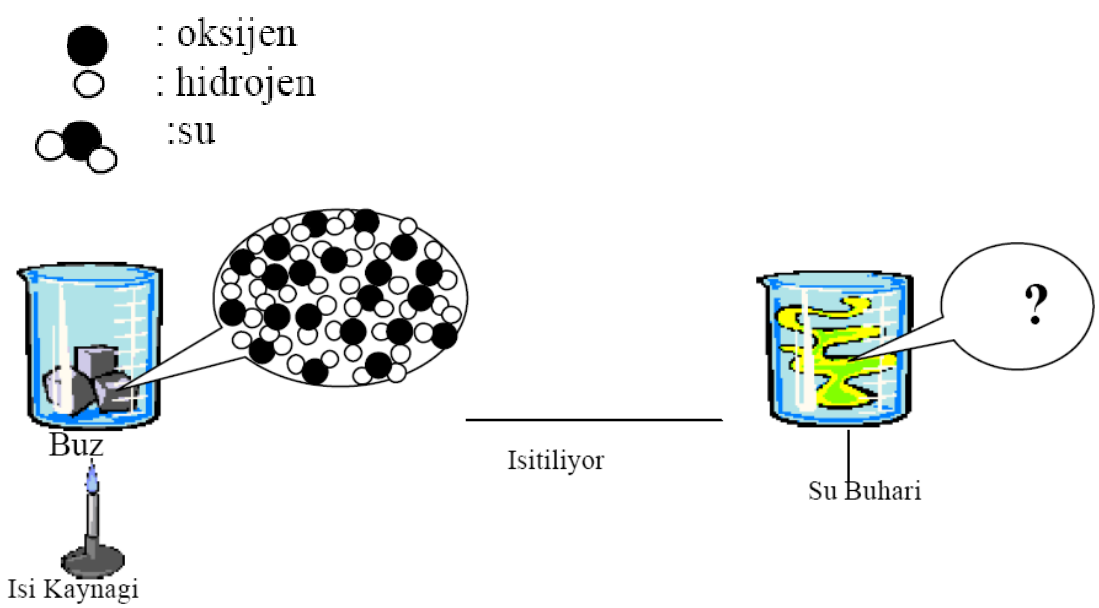
3) Bir atomu aşağıdaki yollardan hangisi(hangileri) ile görebiliriz?
I. nesneleri elimizde inceleyerek
II. normal bir mikroskop ile (ışık)
III. elektron mikroskobu ile
IV. atomlar henüz görülemiyor, ancak gelecekte bazı buluşlar yapılarak görülebilecek
V. insanoğlu atomu hiçbir zaman göremeyecek

a) Yalnız II   b) Yalnız III   c) IV ve V   d) I,II ve III

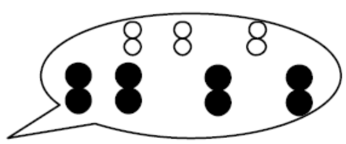
4) Aşağıda verilen bilgilerden hangisi kimyasal bir değişmeden **önce** ve **sonra** aynıdır?
a) maddelerin kütlelerinin toplamı
b) değişmeden önceki ve sonraki toplam molekül sayısı
c) değişmeden önceki ve sonraki toplam atom sayısı
d) a ve c

5) Bir cam çaydanlıkta bir miktar saf suyun 30 dakika kaynadığını düşünün. Sizce kaynayan suyun içindeki baloncuklar nelerdir?
a) hava
b) oksijen ve hidrojen gazları
c) su buharı
d) ısı

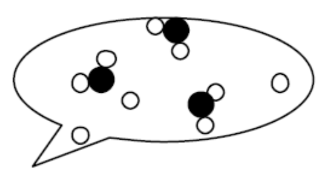
6) Aşağıdaki şekilde, kapalı kaptaki buzun küçük bir miktarının büyütülmüş hali sağdaki dairede gösterilmektedir. Su buharlaştıktan sonra sağ taraftaki daire içinde su buharının büyütülmüş hali nasıl görünür?



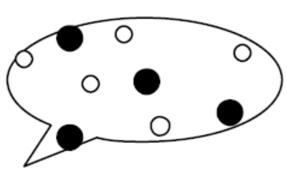
a)



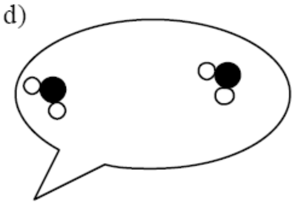
b)



c)



d)



7) 100 gram suda 20 gram tuz çözündüğünde karışımın toplam kütlesi nedir?
a) 80 gram

b) 100 gram
c) 120 gram
d) 120 gramdan fazla

8) Aşağıdaki balonlardan birinciye 10 gram su, ikinciye 10 gram su buharı konularak ağızları kapatılıyor. Balonların içindeki maddelerin yoğunlukları arasındaki ilişki hangi seçenekte doğru verilmiştir?

I

10 gram su (sivi)

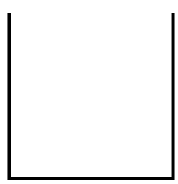
II

10 gram su buhari (gaz)

a) I>II b) II>I c) I = II d) bilinmiyor

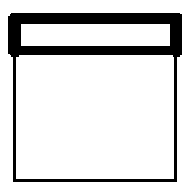
9) Aşağıdaki seçeneklerde verilen nesnelerin hangisinde hava yoktur?

a)



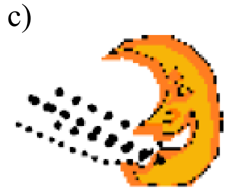
Ağzı açık kutu

b)



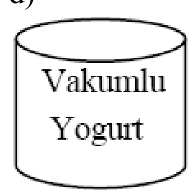
Ağzı kapalı kutu

c)



Ağzımızdan çıkan nefes

d)



Vakumla doldurulmuş yoğurt kasesi

BÖLÜM II) AŞAĞIDAKİ SORULARIN "A" BÖLÜMLERİNDE SORUNUN YANITINI UYGUN SEÇENEĞİ YUVARLAK İÇİNE ALARAK İŞARETLEYİN. "B" BÖLÜMLERİNDE İSE YANITINIZIN NEDENİNİ DOĞRU SEÇENEĞİ YUVARLAK İÇİNE ALARAK AÇIKLAYINIZ.

1) A) Aşağıda listede verilenlerden hangisi ya da hangileri maddedir?
I. demir çubuk
II. kedi tüyü
III. elektrik

IV. sıcak su
V. hava

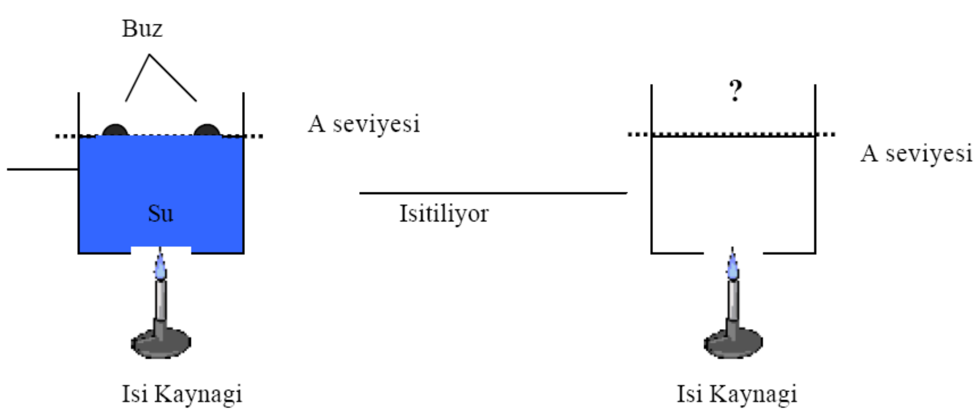
a) demir çubuk, kedi tüyü, hava
b) kedi tüyü, elektrik ve sıcak su
c) demir çubuk, kedi tüyü, elektrik ve sıcak su
d) demir çubuk, kedi tüyü, sıcak su ve hava

B) Madde olduğunu düsündüğünüz nesnelerin **neden** madde olduğu aşağıdaki seçeneklerden hangisinde doğru verilmiştir?
a) çünkü gözümüzle görebilir, elimizle dokunabiliriz
b) çünkü cisimdir
c) çünkü uzayda yer kaplar ve belli bir kütlesi vardır
d) çünkü şekli vardır

2) A) Bir kibrit çöpü yandığında, kütlesinde azalma olur. Bu bilgi doğru mudur / yanlış mıdır? Aşağıda uygun yere "X" işareti koyarak yanıtlayınız
1. Doğru ________________
2. Yanlış_________________

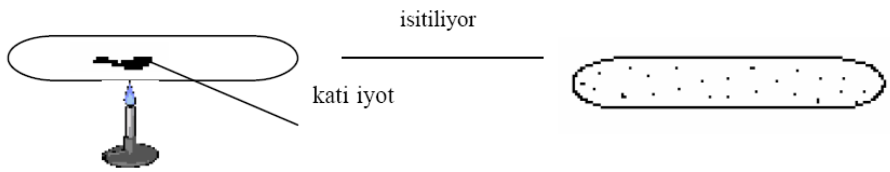
B) Yanıtınızın nedeni aşağıdakilerden hangisidir?
a) atomlar yok edilmedi, kimyasal değişme sonucunda yeniden düzenlendi
b) kibrit çöpü yandığında kütlesi azalır
c) külün kütlesi, kibrit çöpünden azdır
d) kimyasal değişimler maddeleri yok eder

3) A) Iki buz tanesi aşağıdaki kaptaki suda görüldüğü gibi yüzüyor. Kap ısıtılıp, buzlar eridiğinde kaptaki suyun seviyesi ne olur?



a) A seviyesinden yukarıda
b) A seviyesinde
c) A seviyesinin altında

B) Yanıtınızın nedeni aşağıdakilerden hangisidir?
a) buz eritildiğinde molekülleri genleşir
b) eriyen buzlar suyun seviyesini değiştirir (arttırır)
c) suyun yoğunluğu buzun yoğunluğundan daha fazladır
d) su molekülleri, buz moleküllerinden daha fazla yer kaplar

4) 

A) Bir gram katı iyot bir tüpe konuluyor. Tüpün içindeki hava tamamen alındıktan sonra tüpün ağzı kapatılıyor. Tüp ve iyodun toplam kütlesi 27 gramdır. Daha sonra tüp ısıtılıyor ve içindeki katı iyot tamamen gaz hale geliyor. Bu durumda, tüpün toplam kütlesi aşağıdaki seçeneklerden hangisi doğru olarak verilmiştir?
a) 26 gram gelir
b) 27 gram gelir
c) 28 gram gelir
d) 28 gramdan fazla gelir

B) Yanıtınızın nedeni aşağıdakilerden hangisidir?
a) gaz bir madde katı bir maddeden daha hafiftir
b) gaz haldeki iyot, katı haldeki iyottan daha hafiftir
c) iyot gazı havadan daha hafiftir
d) Kapalı sistemlerde hal degisimi sırasında kütle korunur

5) A) Demir metali havadaki oksijenle birleşerek paslanır. Demir bir çivi tamamen paslandırılırsa, paslı çivinin kütlesi aşağıdaki seçeneklerden hangisinde doğru verilmiştir?
a) paslanmış çivinin kütlesi paslanmamış çivinin kütlesinden daha azdır
b) paslanmış çiviyle paslanmamış çivinin kütlesi aynıdır.
c) paslanmış çivinin kütlesi paslanmamış çivinin kütlesinden daha fazladır.

B) Yanıtınızın nedeni aşağıdakilerden hangisidir?
a) paslanma çiviyi hafifletir
b) paslı çivi,demir ve oksijen içeren bir bileşiktir
c) çivinin en dış tabakası soyulur
d) çivideki demir yok olur
BÖLÜM III) Bir sınıfta element ve bileşiklerle ilgili yapılan etkinlikte öğrencilerden değişik renklerde oyun hamuru kullanarak element ve bileşik modelleri yapmaları istenir. Öğrencilerin yaptığı modeller aşağıda verilmiştir. Bu modellerle ilgili aşağıdaki soruları yanıtlayınız.

I.  II.  III.  IV. 

1) Modelleri çizilen maddelerden hangileri **bileşiktir**?
a) I, II b) I, III c) II, IV d) III, IV

2) Modelleri çizilen maddelerden hangileri **elementtir**?
a) Yalnız III b) I, III c) II, IV d) III, IV

3) Yukarıdaki maddelerden hangileri **molekül**, hangileri **atomdur**?
a) I: molekül, II: molekül, III: atom, IV: molekül
b) I: atom, II: molekül, III: atom, IV: molekül
c) I: atom, II: molekül, III: molekül, IV: molekül
d) hepsi molekül

BÖLÜM IV) Iki öğrenci fiziksel ve kimyasal değişmeler konusunu proje olarak sınıfta sunacaklardır. Sunumları için 2 ayrı deney yapmaya karar verirler.
I. öğrenci bir miktar suyu ısıtarak buharlaştırır,
II. öğrenci sudan elektrik enerjisi geçirerek suyun elektroliz olmasını sağlar

Aşağıdaki soruları yapılan deneylere bağlı olarak yanıtlayınız.

1) Öğrencilerden hangisi kimyasal, hangisi fiziksel değişime örnek vermiştir?
a) I. öğrenci : kimyasal değişim
II. öğrenci: fiziksel değişim
b) I. öğrenci : fiziksel değişim
II. öğrenci: kimyasal değişim
c) ikisi de fiziksel değişime örnek vermiştir
d) ikisi de kimyasal değişime örnek vermiştir

2) I. öğrenci yaptığı deneyin sonucunda aşağıda verilen maddelerden hangisini elde etmiştir?
a) gaz haldeki oksijen ve hidrojen molekülleri
b) suyun atomları
c) su buharı molekülleri
d) gaz haldeki oksijen ve hidrojen atomları

3) II.öğrenci yaptığı deneyin sonucunda aşağıda verilen maddelerden hangisini elde etmiştir?
a) gaz haldeki oksijen ve hidrojen molekülleri
b) suyun atomları
c) su buharı molekülleri
d) gaz haldeki oksijen ve hidrojen atomları

APPENDIX J

SAMPLE OF INVENTORY

Kavram Haritaları

1. Daha önce kavram haritası oluşturdunuz mu? Kaç tane?

8 tane

2. Hangi türlerde kavram haritaları hazırladınız?

Yıldız, Hiyerarşik

3.Genel olarak hangi konularda kavram haritaları hazırladınız?

Eğitim metodları ve ilköğretim fen bilgisi konuları

4.Sizce kavram haritalarının kullanılmasına daha uygun olan alanlar var mı? Bu alanlar sizce kavram haritası kullanımına neden daha uygun?

Kavram haritaları sistematik bir bilgi ağının olduğu her alanda kullanılabilir. Ben eğitim alanında kullandığım için gayet uygun olduğunu düşünüyorum. Özellikle fen konularındaki kavramlar arası ilişkiler çok net sergilenebiliyor.

5. Kavram haritalarını yararlı buluyor musunuz? Neden ?

Evet. 4. sorunun cevabında da yazdığım gibi ilk bakışta ilişki olmadığını düşündüğümüz kavramların arasındaki bağlantıları fark edebiliyoruz.

→

Kavram Haritası-1

6.Kavram haritası oluştururken nelere dikkat edersiniz?

İlişkilerin tamamının bulunması gerekir ve tabi doğru kurulmaları gerekir.

7.Kavram haritası oluştururken izlediğiniz belirli bir strateji var mı? Varsa genelde nasıl bir strateji izliyorsunuz?

Konunun temelindeki kavramı ilk başta yazıp ona bağlı olanları sırayla yerleştiriyorum. Yani sırasıyla detaya iniyorum.

8.Gelecekteki öğretmenlik yaşantınızda kavram haritalarını kullanmayı düşünür müsünüz? Neden?

Evet. Bu dönem aldığım ders için kavram haritaları oluşturmanın dışında, önceden de kullandığım bir yöntemdir. Konuyu anlamamı ve daha uzun süre aklımda kalmasını sağlıyor. Zihnimdeki şemayı oluşturabiliyorum.

9. Gelecekte kavram haritası kullanmayı düşünüyorsanız, çoğunlukla hangi tür kavram haritaları kullanmayı tercih edersiniz? Neden?

Daha çok hiyerarşik kullanırım sanırım. Başta genel kavramı görüp, alta doğru ayrıntıya inmek daha kolay oluyor.

Katıldığınız için teşekkürler...

Kavram Haritası-2

APPENDIX K

SAMPLE OF INTERPRETATIVE ESSAY

A
Y

Yorumlayıcı Deneme Soruları

1. Kavram haritanızı oluşturmaya nasıl başladınız?

Önce konu hakkında bilgi sahibi olmak için konuyla alakalı bir sheet okudum. Sonra kavramları ilişkilerine göre haritaya yerleştirdim.

2. Kavramları ve ilişkileri yerleştirmeden önce neler düşündünüz?

Genel olarak kavramları kafamda ilişkilendirdim.

3. Kavram haritanızı oluştururken isimlendirme (isim verme) sürecinde neler yaptınız? Bazı kavramları ve ilişkileri sildiniz mi? Tekrar yazdığınız kavramlar oldu mu? Neden?

Ana fikirleri ortaya aldım. İlişkileri araya yazdım. Genelde silmedim sadece kelimeleri (ilişkiyi gösteren) değiştirdim aynı anlama gelen farklı kelimeler kullandım.

4. Kavram haritanızı oluştururken herhangi bir strateji izlediniz mi? Üst kavramdan alt kavrama ya da alt kavramlardan üst kavrama doğru? Bu stratejiyi seçmenizde etkili olan sebepler nelerdi?

Her zaman konunun ana kavramını ortaya alırım. Sonra ondan akla çıkacak diğer kavramları ilişkileriyle yerleştiririm. Kısa ve özet şeklinde olmasına özen gösteririm. Genelde özele gitmeyi tercih ederim.

→

5. Kavram haritanızda hangi bölümleri daha kolay oluşturdunuz? (İsimlendirme, Dallandırma, ilişkileri kurma) Neden?

Aslında konu hakkında yeterince bilgi sahibi olursa her bölüm kolay olur. Ama ben ilişki kurmada zorlandım bu kavram haritasını çizerken. Diğer bölümler kolaydı.

6. Kavram haritanızı oluşturma sürecinizde herhangi bir sorunla karşılaştınız mı? Karşılaştıysanız bu sorunları nasıl çözdünüz?

Kavram haritasını çizmek için kullanılan aleti pek iyi bilmediğim için o konuda biraz sorun oldu.

7. Seçilen konu kavram haritanızı oluşturma sürecini etkiledi mi? Nasıl?

Evet. "Cell" yerine bilmediğim (daha önce) bir konu olsaydı daha uzun sürebilirdi.

8. Kavram haritanızı oluşturmanız aşamasında size verilen çalışma kağıdı yararlı oldu mu? Hangi açılardan?

Evet. Kavramları hatırlamama yardımcı oldu.

Katıldığınız için teşekkür ederim.

APPENDIX L

SAMPLE OF GAZEPLOT

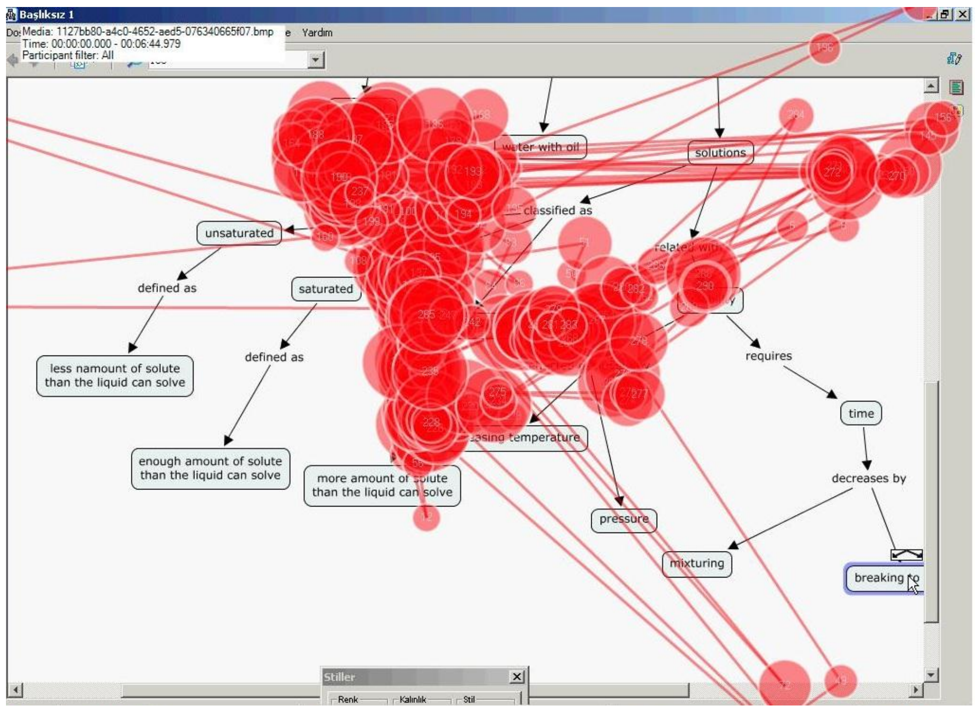


Figure L. 1. Sample of Gazeplot

APPENDIX M

CODES AND THEMES (CM INVENTORY)

CM type preferences	**Prior CM experiences on different subjects**	**Suitable subject areas for CM**	**Reasons for preferring specific areas for CM**	**Future usage of CM in education**	**Advantages of CMs**	**Embraced strategy**
○ Hierarchical ○ Spider & Star ○ Mixed & Both **Future selection on the type of CM** ○ Hierarchical ○ Spider & Star ○ Mixed /Both ○ None	• Education related subjects ○ Methods of education ○ Classroom management • Science related subjects ○ NOS	• Education • Science ○ Biology ○ Physics ○ Chemistry • Social Science ○ History ○ Social studies • Other Areas ○ Language teaching ○ Orienting new staff ○ Complex topics & every topic	• Suitability of the nature of subject ○ Comprising rich amount of concepts • Easiness of representing complex relations • Increasing memorability and comprehensibility of the subject matter • Advantage of visual representations of the content ease the associations	• Introducing the subject • Repeating the previously learned subject • Summarizing the content effectively • Using for assessment purposes	• Potential of conceptualizing the whole picture • Helping to realize unforeseen relations • Highlighting the important points and relations • Preventing misconceptions ○ Determining the misconceptions easily • Potential as an assessment tool	• Deductive ○ Decision making ○ Type of CMs ○ Setting a goal ○ Planning ○ Grouping the concepts and relations in terms of priority ○ Determining branches ○ Placing the main concept • No specific strategy ○ Summarizing the content ○ Grouping logically ○ Using short and meaningful sentences

Table M. 1 *Codes and Themes (CM Inventory)*

APPENDIX N

CODES AND THEMES (INTERPRETATIVE ESSAY)

Written Data
Interpretative essay codes and themes

General Strategy	**Starting strategy**	**Revisions and reasons**	**Easiness of some stages and their reasons**	**Perceived challenges and obstacles**	**Subject matter effect**
• Deductive strategy ○ Easing the comprehensibility ○ Helping to trace the missing points ○ Suitability of subject to deductive thinking ○ Prior experiences ○ Feeling comfortable • Determining the type of the CM (hierarchical & spider)	• Planning a deliberate strategy in mind ○ Determining basic concepts and sub concepts ○ Finding proper relationwords ○ Decision on branch construction ○ Direction of arrows ○ Planning how to position the concepts ○ Conceptualizing the best words • No deliberate strategy	• Concerns on keeping simple • Realizing missing or inaccurate points • Finding a better position • Finding a better representation • Preventing redundancy	• Writing concepts • Branching • Establishing relations	• Tool related • Language proficiency related • Subject matter related	• Familiarity to subject matter eases the process • Suitability of branching • Avoiding the too general concepts ○ Causing organizatio n problems

Table N. 1. *Codes and Themes (Interpretative Essay)*

APPENDIX O

CODES AND THEMES (RETROSPECTIVE REVIEW)

Language effect on Concept Mapping	**Future Plans for concept mapping**	**Potential areas for education**	**CM Tool & Paper-Pencil**	**General Strategy**	**Problems related with Tool**	**Subject Effect**
• Language Structure difference ○ Problems related with linking words • Advantages & disadvantages of using different languages	Potential benefits of concept maps • Providing a good summary • Easiness of checking the misconceptions • Potential as an assessment tool • Advantages of its memorable structure	• Introducing a subject • Assessing the knowledge • Summarizing the subject	• Cost effectiveness • Usability of the tool • Enabling better design possibilities ○ Easiness of modification • Enabling well information representation	• Deductive & Inductive ○ Organization of information ○ Filling information in an order • Embracing hierarchical & spider maps • Branch construction ○ Mirror image ○ Completion a branch	• Limited practice with tool • None	• Feeling comfortable and self-confident • Suitability to elaboration • Being familiar to the topic

Table O. 1. *Codes and Themes (Retrospective Review)*

CURRICULUM VITAE

PERSONAL INFORMATION

Surname, Name: Doğusoy, Berrin
Nationality: Turkish (TC)
Date and Place of Birth: 18 Kasım 1981, İzmir
e-mail: berrindogusoy@gmail.com

EDUCATION

Degree	**Institution**	**Year of Graduation**
Ph.D.	METU-Computer Education & Instructional Technology	2012
BS	Ankara University- Computer Education & Instructional Technology	2003
High School	Salih Dede High School, İzmir	1995

WORK EXPERIENCE

Year	**Place**	**Enrollment**
2004-Present	METU- Computer Education & Instructional Technology	Research Assistant
2005-2010	Turkish National Agency- Leonardo da Vinci Programme	National Independent Expert
2003-2004	Hatay- Reyhanlı Yatılı Bölge Elementary School	Computer Teacher

FOREIGN LANGUAGES

English (Advanced level)

PUBLICATIONS AND PRESENTATIONS

Baturay, M.H., Sancar, H., Dogusoy, B. & Daloglu, A. (2011). The Impact of Task Type on Oral Performance of English Language Preparatory School Students. *Hacettepe University Journal of Education*. 41 (60-69)

Cukurbasi, B., Colak, C., Dogusoy, B. & Baran, B. (2010). Views about Second Life Use in Education: A Case of Turkey. *Paper presented at the Association for Educational Communications and Technology(AECT) Conference* , Anaheim, USA.

Dogusoy, B. & Cagiltay, K. (2009). An Innovative Way of Understanding Learning Processes: Eye Tracking. In J. Jacko (Ed.): Human-Computer Interaction, Part IV: Interacting in Various Application Domains, HCI 2009, LNCS 5613, 94-100, DOI: 10.1007/978-3-642-02583-9_11. Springer-Verlag Berlin Heidelberg.

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Dogusoy, B. (2010). Experts' & Novices' Concept Map Formation Process: An Eye-Tracking Study. Doctoral Consortium, ECTEL 2010, Barcelona.

HOBBIES

Scuba Diving, Sculpture, Travelling