

Experts' & Novices' Concept Map Formation Process: An Eye-Tracking Study

Berrin Dogusoy

Middle East Technical University / Faculty of Education
Department of Computer Education and Instructional Technology, Ankara, Turkey
bdogusoy@metu.edu.tr

Abstract: The purpose of this study is to explore how concept map formation process carried out by individuals who are designated experts and novices. As a group of novice participants, 73 prospective teachers and 5 experts were participated to the study. Data collected by using open ended questionnaires, and retrospective review and eye tracking sessions. These data were used to explore the cognitive process of users during concept map development process. The preliminary results showed that participants tended to follow a deductive approach and in terms of concept map building strategy, there is a pattern among participants starting map with writing links after the concepts.

Keywords: Concept map, eye-tracking, expert, novice, cognitive process

1 Introduction

Concept maps defined as graphical tools for organizing and representing knowledge [1]. They are rooted from cognitive approach, valued among researchers and practitioners for a long time. It is not a new topic for educators, since the effects and benefits of them were explored and mentioned in many research studies. Especially in science education they have been widely used; especially for evaluating the knowledge organization have been used [2], [3], [4]. The literature on concept maps shows that they have been used widely for five categories; including creativity, hypertext design, communication, learning and assessment [5]. The structure of concept maps as a meta-cognitive tool is considered as beneficial, and enhance the understanding with promoting chances to establish relations between exist structure and new knowledge [6]. It is also supported in the literature while explaining Ausebel's basic idea on cognitive psychology on the learning process "learning takes place by the assimilation of new concepts and propositions into existing concept and propositional frameworks held by the learner" [1]. According to them this knowledge can be seen as the cognitive structure of individuals. For this reason, concept maps as a good way to represent knowledge of participants in order to comprehend the conceptual understanding of participants and they need to be explored with considering

the cognitive processes of the human beings [1]. The importance of concept mapping in terms of the role in the process of demonstrating the individual perceptions on subject, more willingly than copying the memorized facts emphasized [7]. The uniqueness is another key point that every map has its special structure since every individual constructs very different maps because of the comprehension of content and knowledge that they acquired [6]. However, like our views, the tools and their usage were changing with respect to the needs of the learner and teacher, and this affects the learning process and researchers' position and interests directly. In recent years, concept maps are started to be used in many fields and for diverse purposes. The common usages of concept maps were using filling maps [8] using concept maps as assessment tools while considering the issue of reliability and validity [4] using different linking phrases in concept mapping [9] and investigating the feasibility of online concept maps [10]. The frequently explored characteristics of concept maps are the hierarchical structure, cross-links and as well as specific examples related with the maps.

As discussed above, concept maps are beneficial tools as they provide an environment for representing the verbal knowledge visually. As constructivism emphasize the importance of knowledge construction of learner and concentrate on the active participation in this process, concept maps valuable tools for implementing this. Even the emphasis is more on learner than the instructor; the assessment is still a problem. Using concept maps as assessment tools and considering them with scoring the concept, link and cross-link number is a well-known and still being used method. In this process some of the researchers proposed techniques on counting the number of the links, concepts or cross links. Although the process requires an assessment step to gather information on the process in terms of the quality of the maps, counting the content of maps may not be an effective strategy. Concept maps are effective tools with their visual structure also for this purpose. Moreover, exploring the construction process is critical that it centralizes the learner and suits to the constructivism's fundamentals with this respect. Although, many research studies have focused on the practical applications of concept maps [11], there has been limited number of studies dealing with the construction process of the concept maps.

The main purpose of this study is to understand the process of concept map development. With this respect, secondary purposes were emerged as exploring the angles of designated experts' and novices' concept mapping process whether there are patterns among novices and experts' concept map development process regarding their cognitive processes. Specifically, the process will be determined whether there are explicit similarities or differences among the novices and between experts. It is aimed to propose a common model for concept map development. The cognitive dimension will give chance to see the differences between individuals in terms of their expertise and how it affects the map development directly. This study is not interested in scoring because the process includes much more than acquiring an end-product. The construction 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 detailed. As a result, exploring concept map

development process became critical process that it includes visual representation of the existing information by forming relations among concepts. Determining the reasons of ineffective concept map usage and the deficiencies of individuals might be explored easily and effectively. This process is also crucial for determining the reasons of ineffective concept map usage and also the deficiencies of the learners are explored more easily and effectively with considering the reasons lying beneath.

2 Research Method and Procedures

As a research methodology mixed method research was selected including stages following one after another. The process can be considered as a prototyping cycle process and all these sections were presented through this context. With this respect, three research studies were conducted for exploring the cognitive process of the participants with examining their concept map development process.

2.1 Research Questions

1. How does concept map development process actualized?
 - How does concept map development processes differ within designated novices and experts?
 - Is there a relationship between levels of use of different concepts and levels of expertise? How can we improve novices to expert level?
 - What are the factors that affect experts' and novices' concept map construction process?
 - Do novices and experts use specific strategies during the concept map development process?
 - Are there differences among experts' and novices' concept maps in terms of content richness and structure of map? If so, could these differences be used to determine their expertise levels?

In the first study, the participants were asked to develop a concept map and their eye movements were recorded and analyzed. The second study carried this study one step further with a different group of participants. In addition to the eye movement recording process, participants were asked to fill a form called as "interpretative essay" includes questions regarding concept map formation process. With these questions it was aimed to understand the cognitive process of the individuals by validating the process with the responses coming from themselves. The last study can be considered as a combination of the previous two studies. Since the participants' responses could not provide a detailed picture on their cognitive process, the researcher changed her strategy instead of asking

for subjects to write their acts and concept mapping process, they were requested to talk about their behaviors in this process. This process called as debriefing session or retrospective review. During this process the participants watched their own concept map developing video which was recorded by eye tracking device and they were asked about the specific steps and acts in this video. This process recorded by voice recorder to have a better understanding about subjects' comments and explanations.

The reasons for using different groups and different techniques during the data collection due to the problems occurred in the process. While starting the research 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. In the second phase, the researcher collected data with using different instrument than the first phase; however the participants did not want to write more about the process because the data collection process is frustrating for them. They expressed that they could not explain their feelings in detail. Hence, the researcher asked them to do another concept map with using an easier way as debriefing session from the video, and add another dimension to the study as expertise. These three phases can be seen as extensions of each other, in other words these three studies were independent but associated cases. Each case examined independently and each phase contributed to the other phase like the former step carried to the existing step to one step further.

2.2 Preliminary Results

The preliminary results of the first study showed that, all participants tended to follow a deductive approach. They have started with placing the main concepts and then they established the sub concepts and links with considering the relationships between the main concepts. The main thought lying under beneath is starting with the main concept and going into deeper concepts. In addition to this, it is observed that they had an established pattern of behavior in terms of putting the links and concepts which is a synchronized manner. Moreover, in terms of the concept map building strategy, almost all participants started to construct concept maps with writing the links and after that the concepts were written. Two of the participants used different way that they started by writing the concepts first and after that they wrote the related links. However, these exceptional participants who started with the concepts and continue with the links changed their patterns after average 3 minutes into writing the links before concepts. The average completion time period was 18.72 minutes for all participants. The minimum time period for building concept map is 9.48 minutes and the longest period was 29.39 minutes with $SD=6,5801$.

In terms of the visual representation of the concept maps almost all participants constructed hierarchically built concept maps. Although some of the participants started to form concept maps which have star structure, they included some branches into the maps and the structure changed into a hierarchic manner. In the concept map formation

process, some specific acts were observed as labeled by researcher. These main acts and the time period spent were analyzed by eye tracking device. This gives opportunity to consider the time frame of the participants while looking at the concepts and links. In addition to this, the reasoning process and arrangement process were analyzed for having an idea on the participants' cognitive structure

3 PhD's project contribution and significance

Although concept mapping is a greatly researched area, many of the studies just focused on the potential of concept maps as in the assessment process and evaluation of the concept maps. Especially, the angles of experts and novices are not a well researched issue for researchers. This study might contribute to the literature, since it has potential to fill the gap on this issues and this study has a combined perspective under the same umbrella while exploring different dimensions related with learning and knowledge structure. Even though every dimension might be explored by researchers particularly, proposing common models for these issues while integrating them under the same umbrella is not an attempted approach. For that reason, this study has a potential to fill this gap while proposing a common model for researchers to be used. This study may help researchers to comprehend their knowledge on expertise and cognitive process with considering the role of concept maps in the learning process.

In addition to this, technological developments effecting field of education like every field. Applications through this also became popular among educators as well as future educators. Since this study includes a technological version of the exist application of concept maps as using paper and pencil. Almost all the students showed an interest to these kinds of applications due to its efficacy and cost-effectiveness than the paper pencil one. This kind of applications and their diffusion among teachers has a significant importance for preventing the resistance to the new technologies and their dissemination. The more teachers and future teacher became aware of the new developments the more they might be willing to use them. Besides, after 2004 the Science and Technology course curriculum structured based on constructivist approach, in Turkey,. This study may offer some practical contributions like helping prospective teachers to use concept maps more effectively in their future teaching life and gaining adequate information about learners. As concept maps are beneficial tools for representing existing knowledge visually and meaningfully rather than memorizing the facts and write down them, this kind of strategies will enable students to analyze and putting through their existing knowledge with new ones while considering their relations. This may provide clues for increasing the quality of the maps and also the perspectives of the learners.

References

1. Novak, J. D. & A. J. Cañas. The Theory Underlying Concept Maps and How to Construct Them. Technical Report IHMC CmapTools 2006-01, Florida Institute for Human and Machine Cognition (2006)
<http://cmap.ihmc.us/Publications/ResearchPapers/TheoryUnderlyingConceptMaps.pdf>
2. Rice, D.C., Ryan, J.M., & Samson, S.M.. Using concept maps to assess student learning in the science classroom: Must different methods compete? *Journal of Research in Science Teaching*, 35.1103-1127 (1998)
3. Ruiz-Primo, M. A., & Shavelson, R. J. Problem and issues in the use of concept maps in science assessment. *Journal of Research in Science Teaching*, 33, 569-600 (1996)
4. White, R. & Gunstone, R. Probing understanding. London: The Falmer Press (1992)
5. Milam, J., Santo, S., & Heaton, L. Concept maps for web-based applications. ERIC Technical Report ED445627 (2000)
6. Kinchin, I.M. & Hay, D.B.. How a Qualitative Approach to Concept Map Analysis Can Be Used to Aid Learning by Illustrating, *Educational Research*, 42 (1), 43-58 (2000)
7. Jonassen, D., Reeves, T., Hong, N., Harvey, D. & Peters, K. Concept Mapping as Cognitive Learning and Assessment Tools. *Journal of Interactive Learning Research*, 8, 3/4, 289-308 (1997)
8. Ruiz-Primo, M. A., Schultz, S.E., Li, M., & Shavelson, R. J.. Comparison of the reliability and validity of scores from two concept mapping techniques. Paper presented at the AERA Annual Meeting, San Diego, CA. (1998)
9. Yin, Y., Vanides, J., Ruiz-Primo, M.A., Ayala, C.C., & Shavelson, R.. A comparison of Two Construct-a-Concept-Map Science Assessments: Created Linking Phrases and Selected Linking Phrases. Center for the Study of Evaluation Report (2004)
10. Herl, H.E., O'Neil, H.F.Jr., Chung, G. K.W.K., Dennis, R.A. & Lee, J.J.. Feasibility of an On-line Concept Mapping Construction and Scoring System. (Paper presented at the annual meeting of AERA, Chicago, IL, March) (1997)
11. Derbentseva, N., Safayeni, F., & Canas, A. J. Concept maps: Experiments on dynamic thinking. *Journal of Research in Science Teaching*. 44(3), 448 - 465 (2007)