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USING CONCEPT MAPS TO EXPLORE PRE-SERVICE CHEMISTRY TEACHERS' CONCEPTUAL UNDERSTANDINGS ABOUT SCIENTIFIC ıNQUıRY AS A SUBJECT MATTER

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Abstract. This paper describes our experience with using concept maps to explore pre-service chemistry teachers' conceptual understandings and to monitor learning outcomes of a new science method course focused on content knowledge of scientific inquiry as a part of our research project. 27 pre-service chemistry teachers participated in the science method course lasted eleven weeks, three hours weekly. The participants performed some simulated activities, real scientific experiments, and engaged in some assessment activities, and watched a video program which involves strong visual images and simple, accessible scientific examples to bring the steps in scientific investigation into view. As an assessment tool, we used a concept mapping technique called construct-a-map with created linking phrases. Before and after the course, the student teachers were asked to construct a concept map using a list of the concepts provided by the researchers. We used a two-tier analysis as the scoring technique; scoring concept map links quantitatively and their structure qualitatively. The results of the Paired Samples t-Test indicated significant difference between the means of pre- and post-concept scores in favor of post-concepts scores. Quantitative and qualitative analysis of pre- and post-concept maps and the distribution graphics of the map scores indicated that pre-service chemistry teachers' conceptual understandings had a significant progress. In addition, it was observed that structure types of participants' concept maps became more hierarchically organized and differentiated. It is also obvious that the findings from analysis of the pre-service chemistry teachers' concept maps will be beneficial to revise the first version of the science method course, of which progress is still going on.

1 Introduction

In recent years, the issue of how science is taught to individuals, especially to students, has been more important than it used to be before since the ideas about the nature of scientific knowledge radically changed owning to the work of epistemologists. Therefore, the focus on the nature of science and scientific inquiry in science education reforms of many countries in the world is rapidly increasing (Osborne et.al, 2003). However, the number and the quality of the researches about this topic are not enough. In Turkey, we are studying on a research project supported by TÜBİTAK (The Scientific and Technological Research Council of Turkey) in order to develop original teacher development packages and workshops with the final goal of improving elementary and secondary students' understanding of the nature of science considering recent paradigm shifts about science. When this project is completed science method course and teaching materials, the products of the project, will be a resource and model for training both teacher candidates and in-service teachers. During the science method course development process as a part of the project, we used various assessment tools including concept maps.

Knowledge structure is regarded as an important component of understanding in a subject domain, especially in science. The concept map is a tool, based upon the cognitive psychological theory of constructing meaning, developed by Novak and Gowin (1984) as a convenient and concise representation of the learner's conceptual/propositional framework of a domain-specific knowledge. Concept mapping technique can be used to follow the restructuring and the evolution of the cognitive structure by comparing successive concept maps produced by the student at different stages of the teaching-learning process of a given topic (Mintzes et al., 1997). Therefore, in the development process of a new science method course about scientific inquiry, we thought that it would be reasonable to use the concept mapping technique for monitoring the changes in students' cognitions and also as an assessment device.

The objectives of this study were, in the development process of a new science method course focused on teaching scientific inquiry as a subject matter, (a) to explore the use of concept maps in assessing student teachers' declarative knowledge in the context of the scientific knowledge, and (b) to monitor learning outcomes of the science method course as instructional emphases shift from more basic to higher levels of performs.

2 Methodology

As a part of our research project, we have developed a science method course consisted of two sections for the pre-service chemistry teachers attending fifth year in a five-year Teacher Education Program at a university level in Turkey. The first section of the course was devoted to teaching what science is; and how the scientists do science that is to say scientific knowledge and inquiry by providing students real life examples and practices. The second section, not stressed in this paper, considered and reviewed deeply more theoretical background of

the nature of science. A concept map overviewed the main and sub-concepts related with the science method course was shown in Figure 1. In this paper we report on our experience about the implementation of only first section of the science method course and present analysis of pre- and post-concept maps of the student teachers.

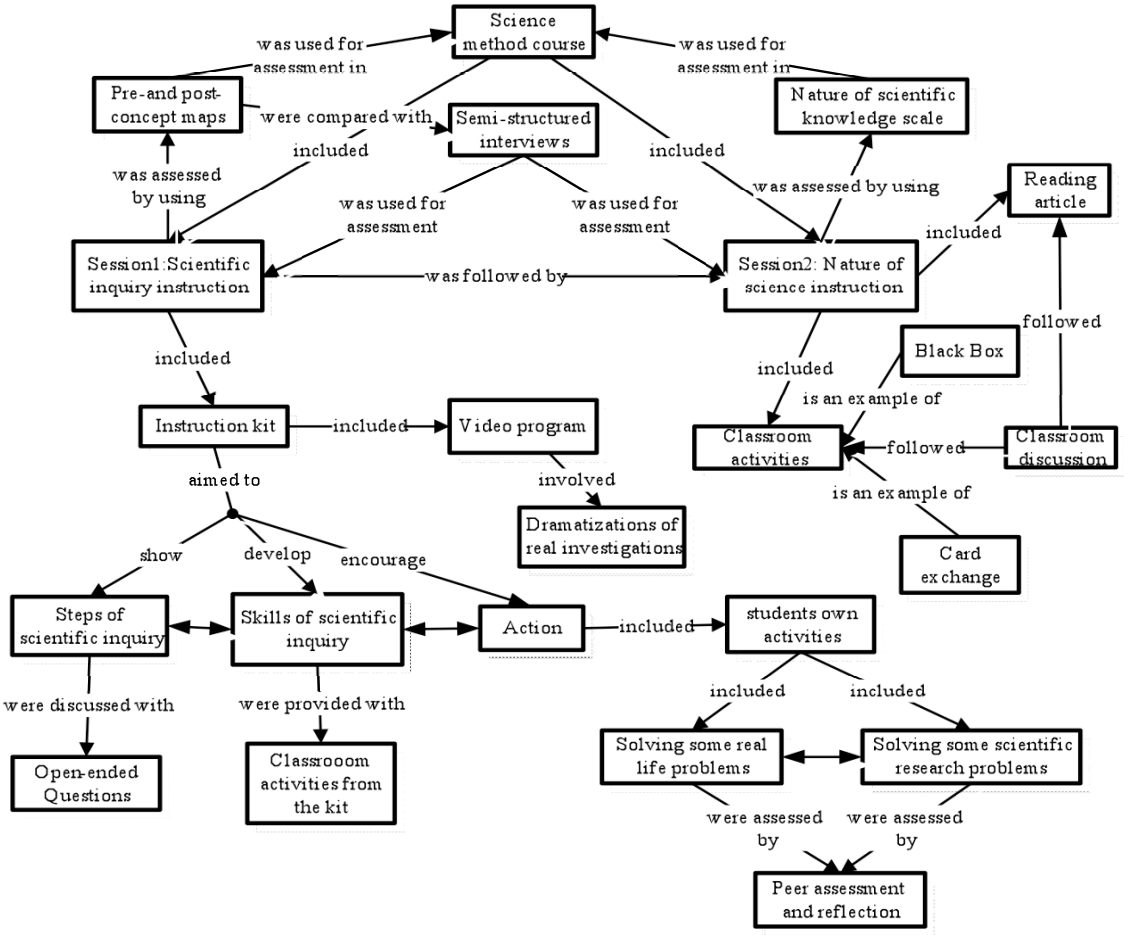

Figure-1. A concept map overviewed the main and sub-concepts related with the science method course

In the first section, we used a commercial kit named *Scientific Inquiry: Steps, Skills and Action* (Friedman and Friedman, 2003). The kit consists of 10 activities, and a video program which involves strong visual images and simple, accessible scientific examples to bring the steps in scientific investigation into view. The video program was translated from English to Turkish and subtitled. Firstly, student teachers watched the program and reviewed the ideas, and participated in small group and whole-class discussions. Then, the students performed some simulated and real scientific experiments by studying in scientist teams and reality teams, and engaged in some assessment activities. According to us, one of the advantages of this approach is that students could see a clear presentation of the steps and ideas involved in scientific inquiry, review these concepts and then use the knowledge in the assessment exercises that we prepared.

Twenty seven pre-service chemistry teachers participated in the first implementation of the course. The course was lasted eleven weeks, three hours weekly. The first three hours of the course were devoted to training participants in the concept mapping technique by introducing them to operational definitions of terms such as concept label, linking relationship, proposition and cross-link. Some maps were constructed on non-scientific subjects. In the course, data were collected by using concept maps, and Turkish version of *The Nature of Scientific Knowledge Scale* in a pre/post format (Taşar, 2006). In addition, the qualitative data were obtained by semi-structured interviews, reflections and peer assessments of student teachers own activities about scientific inquiry. As an assessment tool we used a concept mapping technique, construct-a-map with created linking phrases. This mapping technique characterized as the gold standard of concept maps (Ruiz-Primo et al., 2001). Compared with the fill-in-a-map technique, construct-a-map technique supplies students with more opportunities to determine conceptual understanding; and elicits higher order cognitive processes, such as explaining and planning. However construct-a-map assessments are challenging to score because students' products vary greatly. Researches have proposed various techniques for scoring concept maps (McClure et al.,

1999; Kinchin, 2000). We used the scoring technique which Kinchin (2000) suggested a two-tier analysis, scoring concept map links quantitatively and their structure qualitatively.

Before and after the course, the student teachers were asked to construct a concept map using a list of the concepts provided by the researchers but it was said that they could add any concept if they want. 18 concept labels in the list were; *scientific inquiry, observation, hypothesis, prediction, testing, data, analyzing, conclusion, question, result, refining question, communication, literature, scientist, problem, specific hypothesis, practice and existing scientific knowledge*. Since the objective was to point out the eventual changes in the cognitive structure following teaching of the topic, the same terms were given before and after teaching. The maps were drawn up individually during a normal class session.

3 Result and Discussions

Quantitative analysis of pre- and post-concept maps were carried out by scoring 1 point for each correct linkage or relationship, 5 points for each level of hierarchy and 5 to 10 points for cross-links showing correct relation between two concepts in different sections of the hierarchy (Novak & Gowin, 1984). Each concept map was scored by the researchers together. It was determined that the scores obtained from the concept maps are normally distributed (for both pre-test and post-test $p>0.05$) by using Kolmogorov-Smirnov Test in SPSS program. For the purpose of investigating if pre-service chemistry teachers' understandings of scientific inquiry changed, the mean of pre- and post-concept map scores were analyzed by using Paired Samples t-Test. It was found that there was a statistically significant differences between the means of pre- and post-concept map scores in favor of post concept map scores ($t_{(26)}= -7.243$; $p< .05$). The effect size was computed as 1.3 and shows that the treatment was large effect size according to Cohen's categorization (Cohen, 1988). It means that conceptual understandings of the pre-service chemistry teachers about scientific inquiry had an important progress.

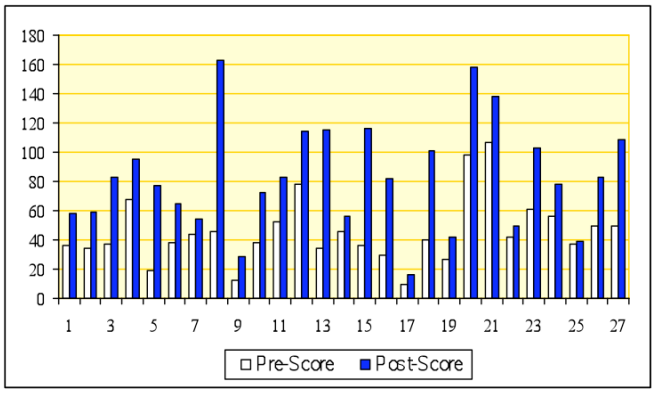

Figure-2. Distribution of the scores

In Figure 2, the distribution graphic of the pre- and post-scores of the students was shown. Analysis of the distribution graphics and the concept maps show that before teaching, 5 of 27 students chose the concept label "*specific hypothesis*" but no one associated it with a suitable concept. After teaching, this concept was used by 25 of 27 students; 12 of these 25 still couldn't link suitable relationship. Analysis also revealed similar results for some concepts such as *refining question and communication.* Figure 3 and 4 show two maps that were constructed by the same student before and after teaching. They are quite different. By comparing the two maps drawn up by each student, changes in the structure of the map were found in more than three quarters of the students. In addition, qualitative analysis showed that structure types of pre-service chemistry teachers' concept maps became more hierarchically organized and differentiated. It is reasonable to think that changes in the maps correspond the similar the changes in the conceptual structure of the student teachers due to participating our science method course. Furthermore, findings of analysis of the data obtained by other assessment tools such as *The Nature of Scientific Knowledge Scale*, semi-structured interviews, reflections and assessment activities were in agreement with those obtained by concept maps.

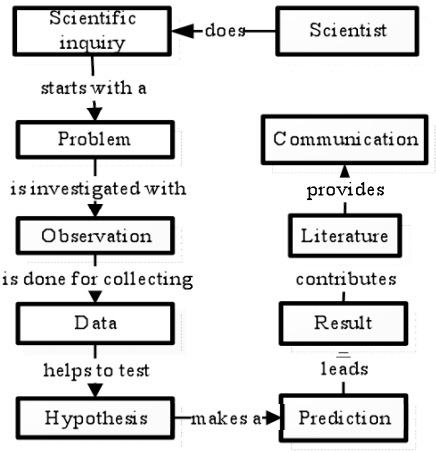

Figure-3. Pre-concept map of one of the participants

Consequently, it is obvious that the findings from analysis of the pre-service chemistry teachers' concept maps will be beneficial to revise the first version of the scientific method course, of which progress is still going on.

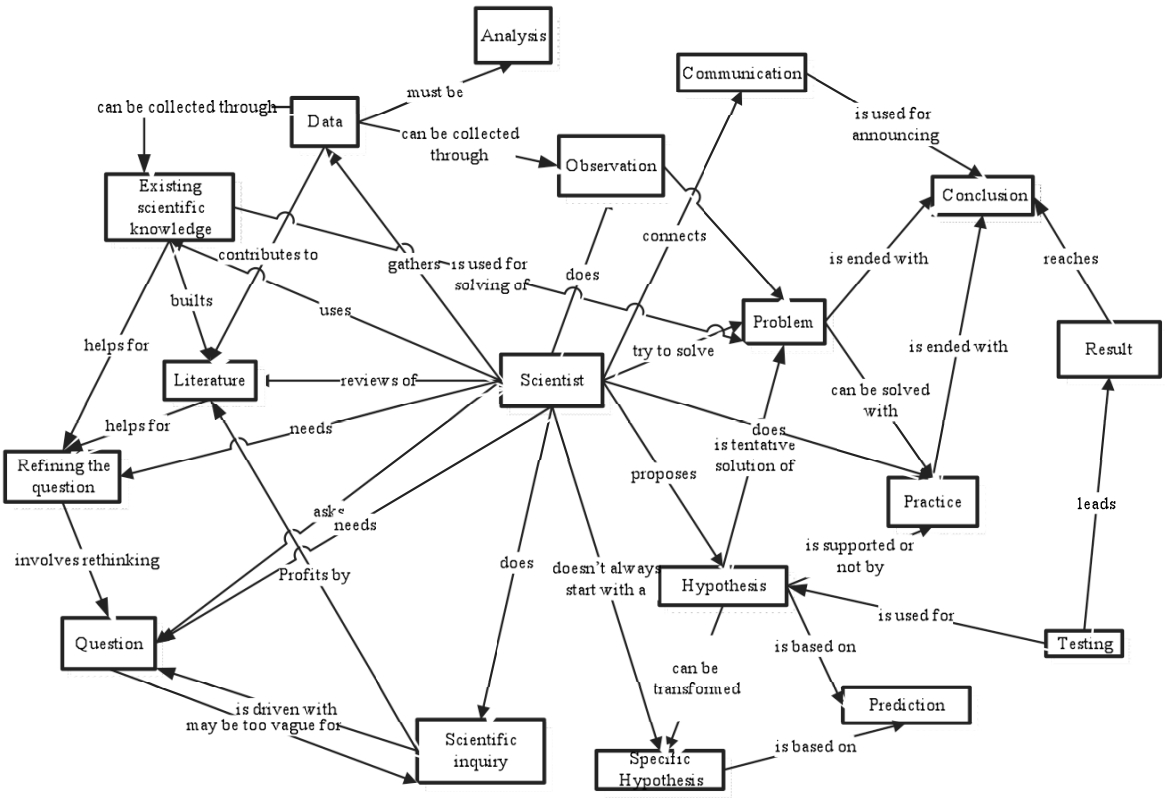

Figure-4. Post-concept map of one of the participants

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