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THE DEVELOPMENT OF A QUALITATIVE ANALYZING METHOD FOR CONCEPT MAPS

KAVRAM HARİTALARI İÇİN NİTELİKSEL BİR ANALİZ YÖNTEMİNİN GELİŞTİRİLMESİ

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ABSTRACT: Concept mapping has been widely used as one of the most efficient methods of revealing the cognitive structure of an individual on any concept. There are not only different concept mapping techniques but also different ways of analysis. It has been suggested that concept maps provide valuable and rich information which becomes disoriented when they are analyzed only quantitatively. This study has described a qualitative analyzing method of concept maps, developed for investigating the cognitive structures of preservice teachers on some educational concepts. An analysis of the relations between the concepts in concept maps is developed and discussed which was neglected by both qualitative and quantitative analyses in the literature. This analyzing method aims to examine concept maps created by pre-service teachers using "construct-a-map-from-scratch" method centred on multiple key concepts which emphasized the categorization of linkage labels and other connected concepts.

Keywords: Concept Maps, Data Analysis, Qualitative Analyses, Preservice Teachers

ÖZET: Kavram haritaları, bireylerin herhangi bir konudaki bilişsel yapısını ortaya çıkarmada en etkili yöntemlerden biri olarak kullanılmaktadır. Değişik kavram haritaları oluşturma teknikleri olduğu gibi farklı analiz yolları da bulunmaktadır. Kavram haritalarının sağladığı zengin ve değerli bilginin sadece nicel olarak incelendiğinde kaybolduğu görülmektedir.Bu çalışma, öğretmen adaylarının bazı eğitim kavramları hakkındaki bilişsel yapılarını ortaya çıkaran kavram haritalarını niteliksel olarak inceleyen bir analiz yöntemini tanıtmaktadır. Kavram haritalarının literatürde olan gerek niceliksel gerekse niteliksel analizlerinde gözardı edilen kavramlar arasındaki ilişkilerin niteliksel analizi geliştirilmiş ve tartışılmıştır. Bu analiz yöntemi, öğretmen adayları tarafından birden fazla anahtar kelime ile "sıfırdan kavram haritası üretme" metodu kullanılarak oluşturulan kavram haritalarını değerlendirmek amacı ile, kurulan ilişkileri ve anahtar kelimelere bağlı kavramları sınıflandırmayı amaçlamaktadır.

Anahtar Kelimeler: Kavram Haritaları, Veri Analizi, Niteliksel Analizler, Öğretmen Adayları

1. INTRODUCTION AND REVIEW OF LITERATURE

Concept maps are two-dimensional node-link diagrams displaying the concepts and the interrelationships among them. Kinchin and Hay (2000) describe a concept map as "a portrayal of mental model" (p. 44) while Jones and Vesilind (1996) characterize it as "a snapshot of the construction of knowledge" (p. 97). Concept maps were originally developed by Novak and the members of his research group in the early 1970s as means of representing frameworks for the interrelationships between concepts (Novak & Gowin, 1984; Stewart, Van Kirk & Rowell, 1979). Concept mapping strategy is constructed on Ausubel's cognitive assimilation and meaningful learning theory (Ausubel, 1968; Novak, 1984). According to this theory, learning becomes meaningful when new knowledge is connected to the previous learning both logically and meaningfully; so that knowledge can be seen as a web which displays connected and interrelated concepts. Moreover, each concept gains a meaning according to its relationships with others.

Researchers and educators have been discussing the value of concept maps and how they make it possible to preview the cognitive structure of individuals (Novak, Gowin & Johansen, 1983). Thus, it

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becomes crucial to consider the ways of creating concept maps and analyzing methods in order to observe and interpret this complex structure objectively and properly as much as possible (Enger, 1996). Some of the techniques of creating concept maps include (Kaya, 2003; Ruiz-Primo et al., 1996, 2001):

- Collaborative Concept Mapping: where individuals create a concept map through discussions and cooperating with each other,
- Fill-in-the-Map: where individuals fill in the nodes of a skeleton map or fill in the linking lines, and
- Construct-a-Map-from-Scratch: where individuals create a concept map on a topic by inserting concepts and links without a restraint.

There are not only different concept mapping techniques but also different ways of analysis:

- Holistic scoring method (McClure et al., 1999): Examining each concept map and judge the mapper's overall understanding of the concepts represented by the map by a score one to ten.
- Relational scoring method (McClure & Bell, 1990 and McClure et al., 1999): Evaluating the separate propositions (as 2 concepts connected by a labelled arrow indicating the relationship between the concepts) by a score one to three according to the correctness of the relationship and total score is calculated by summing of those scores of propositions.
- Structural scoring method (Novak & Gowin, 1984): 1 point for a valid example, 1 point for a valid relationship, 5 points for a valid hierarchy, and 10 points for a valid crosslink.

Although the concept maps have been quantitatively analyzed for a long time as stated above, many educators and researchers argue that most of the data and valuable information are vanished in this kind of analysis (Mason, 1992; Özgün-Koca and Şen, 2003; Stuart, 1985; and Şen and Özgün-Koca, 2003b). Analyzing this complex image of a cognitive structure with just quantitative methods deemphasizes and oversimplifies the qualitative aspects of it:

> Qualitative analyses of the concept maps reveal more cognitive change than the quantitative analyses. (Jensen and Winitzky, 2002, p. 15)

When discussing the assessment methods of concept maps used in classrooms, some educators recommend quantitative methods (Enger, 1996; McClure et al., 1999) while some of them suggest the use of qualitative methods in order to reveal students' understanding (Enger 1998; Kinchin and Hay, 2000).

> We are suggesting here that concept maps should be viewed as a qualitative instrument to aid the process of meaningful learning in the classroom. (Kinchin and Hay, 2000, p.46)

Considering the research aspect, many studies either combined both quantitative and qualitative methods (Beyerbach, 1986; Beyerbach & Smith, 1990; Jensen & Winitzky, 2002; Jones & Vesilind, 1996; Rink et al., 1994; Trent et al., 1998) in order to reveal participants' beliefs or they just utilized qualitative methods (Raymond, 1997). Raymond (1997) made her four participants create their concept maps when interviewing and asking reasons for added concepts and relations in their concept maps. This made the use of sole qualitative analysis possible and she concluded that:

> The activity of concept mapping is such a tool, and it serves as an impetus for designing more avenues for qualitative research. (Raymond, 1997, p.25)

On the other hand, there are different ways of combining qualitative and quantitative methods in the literature, in one of which researchers used quantitative technique (mainly Novak's scoring method or similar one) and a separate qualitative analysis of concept maps where researchers code all or super ordinate concepts in the map into categories (Beyerbach, 1986; Beyerbach & Smith, 1990; Jensen & Winitzky, 2002;

Jones & Vesilind, 1996; Rink et al., 1994; Trent et al., 1998). Sometimes researchers utilized the numbers from qualitative coding and categorization for further comparisons and statistical analysis (VanLeuvan, 1997; Şen & Özgün-Koca, 2002; Şen & Özgün-Koca, 2003b).

2. AIM OF THE STUDY AND DATA COLLECTION METHODS

In this study, a qualitative analyzing method of concept maps has been developed and discussed. The concept maps were created by using "construct-a-map-from-scratch" method centred on *multiple* key concepts. Fifty-one graduating pre-service teachers, 26 in mathematics education (18 female, 8 male) and 25 in physics education (10 female, 15 male) were participated at Hacettepe University in Ankara in 2001-2002 Spring Semester. Preservice teachers were asked to create two concept maps with the same key concepts of "teacher, teaching, student, and learning" before and after the student teaching process with the aim of examining their ideas and perceptions about these key educational concepts (Şen, & Özgün-Koca, 2003a). Although participants were familiar to the idea of concept mapping, one session was spent to summarize and re-introduce the concept mapping techniques. The aim of this study is to present a new concept map analyzing method using the data which was a part of a bigger study.

"Construct-a-map-from-scratch" method has been widely used with one key concept for individuals to create concept maps in order to make one's cognitive structure visible. Sometimes having only one concept can bring both the most relative and irrelative concepts. However, in this study this concept mapping method was used with *multiple* key concepts with the aim of observing the participants' ways of connecting specific concepts. When multiple key concepts were prompted, participants were directed to think about more related parts of their cognitive structure. For instance, "teacher, teaching, student, and learning" key concepts gave opportunity to the researchers to detect epistemological views of the preservice teachers; such as how learning occurs, the roles of teacher and student in the teaching and learning process, and the relationship between teaching and learning. Researchers had the chance to investigate the rest of the cognitive structures by letting the participants add other concepts that they saw related.

3. DATA ANALYSIS

The development of a novel qualitative concept map analysing method has evolved from the need of obtaining the deep qualitative information that lays in the concept maps. The process of developing this method is described in Table 1.

Since preservice teachers were given multiple key concepts, it was necessary to study the connections among those four concepts. As mentioned above, in the qualitative analyzing methods in the literature the

Table 1: The process in a qualitative concept map analyses

Aim	Observing the cognitive structure of preservice teachers on some educational concepts before and the after student teaching.
Processes	*How these 4 key concepts "teacher, teaching, student, and learning" are connected?* Direct linkages, over other concepts or both
	How the direct linkages are titled? Grouping of direct linkage explanations/labels into the categories
	What are other concepts among the key concepts and how many? Counting and grouping of those concepts into the categories
Results	Provided information about how preservice teachers perceive these key concepts and the relationships among them.

concepts were studied and categorized; linkages were not paid attention. In the quantitative analyzing methods, on the other hand, the linkages are scored according to their correctness. However, the need for more in-depth analyses of linkages among concepts was emphasized by many researchers (Raymond, 1997; Enger, 1998). McClure at al. (1999) concluded that "the relational scoring method used in conjunction with a master map yielded the most reliable scores" (p.488) when compared to holistic and structural scorings with and without master maps. Therefore, the connections, linkages and the concepts among those four key concepts were studied and coded into categories with the aim of identifying the preservice teachers' views about the teaching and learning process.

4. RESULTS

The analysis of "student and teacher" concepts is provided as an example in order to explain this new qualitative analyzing method explicitly. In order to examine how preservice teachers connect these two concepts, first the number of direct linkages between the "student and teacher" key concepts were analysed (Figure 1). The number of direct linkages between "Student and Teacher" key concepts increased in the post concept mapping of both groups. Total direct linkages increased from 30 in pre-maps to 35 in post-maps. Mathematics preservice teachers had more direct linkages between these two concepts in both pre-and the post concept mapping than the physics preservice teachers (Figure 1).

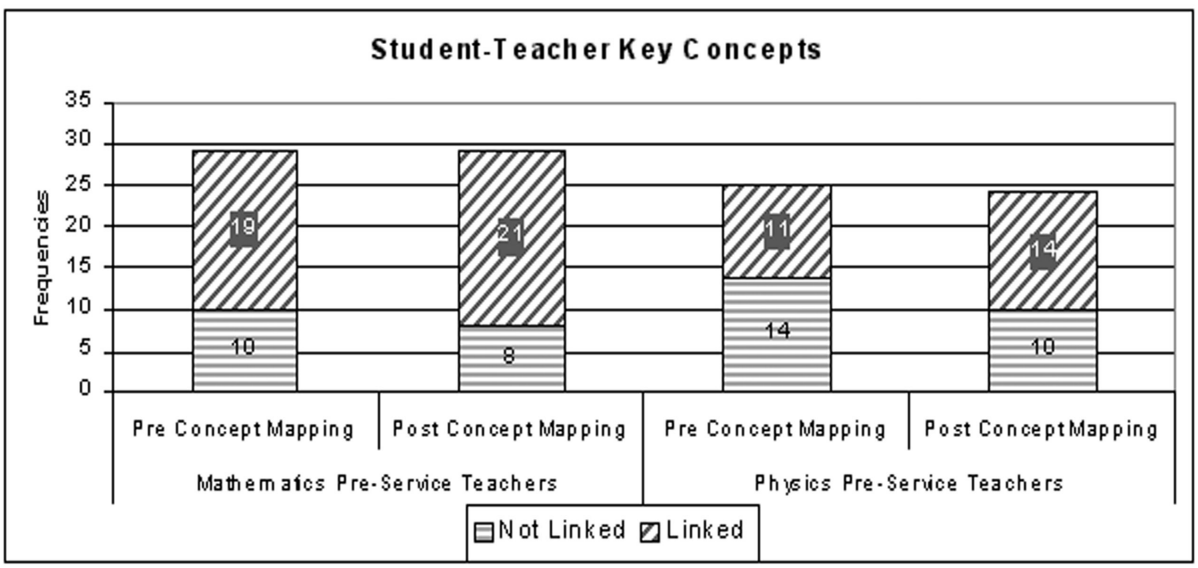

Figure 1: *Frequencies of direct linkages between student and teacher key concepts.*

At the first analysis step, the assumptions of the preservice teachers on the existence of a connection between these two concepts to put a direct connection in their concept maps were investigated. Afterwards, it became more crucial to examine the labels on those direct linkages (Figure 2).

The labels on the direct linkages between "Student and Teacher" key concepts were grouped according to the emerging categories from the data. The interaction/communication between the student and the teacher was one of the main ideas mentioned by many preservice teachers (Figure 2). Keeping in mind that the post concept mapping was after the student teaching, the differences in the pre-and post concept mapping can easily be examined. It can also be observed that preservice teachers assigned teachers both the roles of facilitating and educating/teaching in the teaching and learning process.

A concept map created by a male physics preservice teacher is illustrated in Figure 3. His linkage between "student" and "teacher" key concepts was coded as "interaction" in the analysis. This concept of

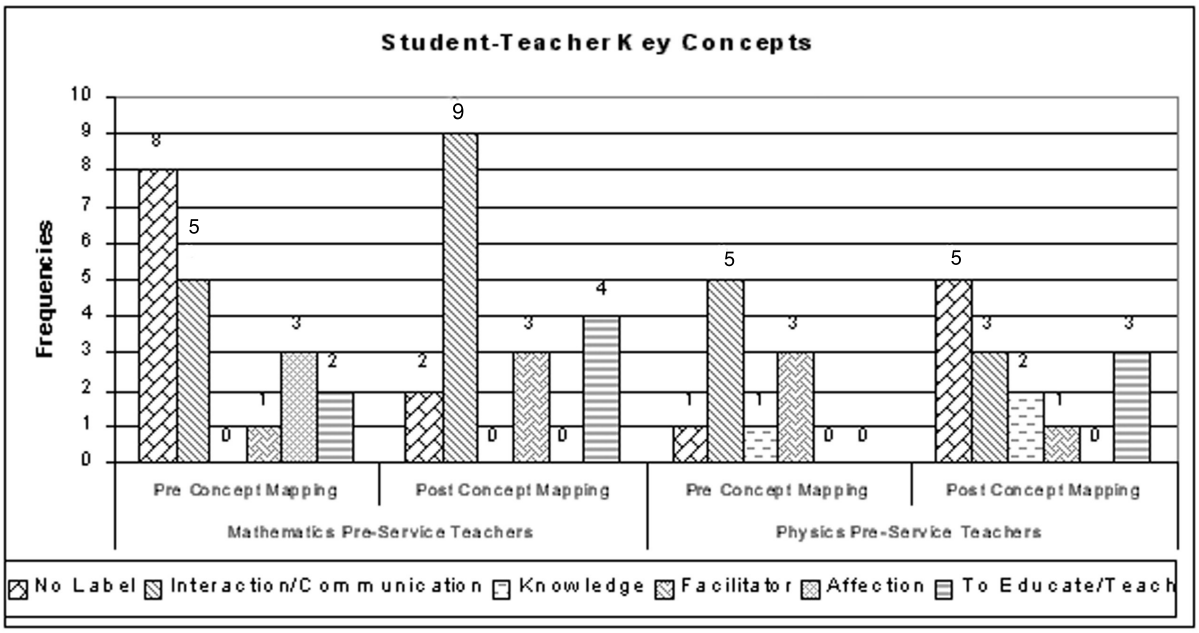

Figure 2: *Categorization of labels of the direct linkages between student and teacher key concepts*

"interaction" is explained in more detail in the concept map. According to him, there are roles of teacher and students which occur interactively. For example, while the teacher lectures, students listen or students study and the teacher evaluates them. Of course, question and answer method was one of the teaching strategies which will create an interaction between students and the teacher.

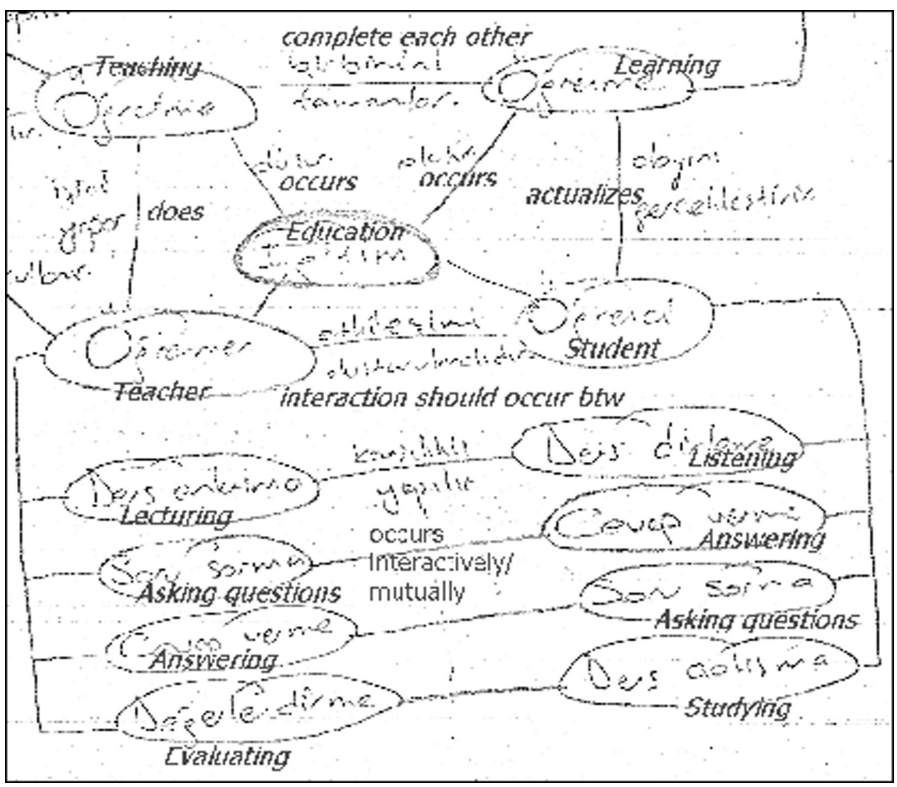

Figure 3: Part of a concept map created by a male physics preservice teacher

Since the nature of the relationship between these two concepts can not only be determined with the explanation on the linkage between them, the other concepts, that they both are directly connected to, are also examined. For instance, "Education" is a concept inserted freely into the concept map and connected to both "student" and "teacher" key concepts directly in the illustrated concept map in Figure 3. Table 2 illustrates the number of concepts connected to "student" and "teacher" key concepts.

Table 2: Number of concepts linked to "student" and "teacher" key concepts

Number of Concepsts Linked to Both Student and Teacher Key Concepts	Number of Concepts	Mathematics Pre-Service Teachers		Physics Pre-Service Teachers	
		Pre CM	Post CM	Pre CM	Post CM
	0	0	2	4	9
	1	4	1	15	5
	2	8	9	4	7
	3	6	9	0	3
	4	4	5	1	1
	5	3	2	1	0
	6	1	1	0	0
	7	1	0	0	0
	8	1	1	0	0
	9	1	0	0	0

As one can observe, although not many physics preservice teachers chose to use direct linkages between these two concepts (Figure 1), they had other concepts that they thought were related to both key concepts (Table 2). Fifteen physics preservice teachers had one concept linked to the two key concepts in the pre-concept mapping; however, only five of them linked one concept with the "student and teacher" key concepts in the post-concept mapping. Many mathematics preservice teachers, on the other hand, had two or three concepts connected to both "student and teacher" key concepts in both pre and post concept mappings.

Again grouping those added concepts between the key concepts into the emerging categories would help the researcher and the interpreters to understand how preservice teachers associated the key concepts (Table 3).

School system was one of the categories that strongly emerged from the data. Some of the examples that coded in this category were school, class, classrooms, educational administration and so on. With this category, preservice teachers were emphasizing the educational environment in their concept maps. Eighteen mathematics and nine physics preservice teachers inserted a concept related to school system in their pre-maps and connected them to both "student" and "teacher" concepts. Since "learning" and "teaching" were other key concepts given at the beginning and closely related to "student" and "teacher" key concepts, it was expected to observe direct linkages among them (Table 3). This table helps us to see not only how preservice teachers relate student and teacher concepts but also other issues affecting this relation; such as their attitudes, teaching methods, and teaching materials. For instance, mathematics preservice teachers chose to add many concepts illustrating their attitudes and affections such as anxiety, fear, and love.

Table 3: Categorization of concepts linked to "student" and "teacher" key concepts

Concepts	Mathematics Pre-Service Teachers		Physics Pre-Service Teachers	
	Pre CM	Post CM	Pre CM	Post CM
Learning	8	7	3	5
Teaching	7	6	1	1
Profession	0	0	1	1
Qualities	3	2	3	1
Teaching Methods	1	1	0	2
Teaching Materials	4	1	0	0
Attitudes/ Affections	7	16	0	0
School System	18	21	9	8
Knowledge	2	6	3	4
Education	14	4	6	5
Evaluation	9	5	1	1
Environment	4	4	2	0
Other	9	14	3	4

5. DISCUSSION

This study utilized "construct-a-map-from-scratch" concept mapping method with more than one key concept allowing preservice teachers to use their creativity while revealing their cognitive structure visually especially on the subjects related to their profession. It proved that the concept maps provide the educators and researchers deep and valuable information about the cognitive structure of the participants. They do not only reveal the concepts that participants think related but also *how* those concepts are related to each other. Particularly, the qualitative analyses of the links and their labels enabled us to investigate the quality of those relationships.

However, this valuable and rich information becomes disoriented when concept maps are analyzed only quantitatively. While quantitative analyzing methods allow us to see just the skeleton of the cognitive structure visually, qualitative methods help us to observe the inside of this skeleton in addition to its organization. Qualitative analysing methods, on the other hand, uncover both the content and the relationships.

Now, it is crucial to decide which method to use, when and with whom or to develop a new analysing method according to the nature of the research question. For instance, this kind of an analysing method was essential for the study that asked the perceptions of the preservice teachers about four key educational concepts twice in different times. An additional aim was to observe the variation in the ideas of the participants over time due to student teaching and field experience. Different methods would be decisive in order to observe and interpret changes over time.

There are discussions about the appropriateness of the use of concept mapping in different languages due to the crucial differences in the language structures. Moreover, there are always individuals who do not prefer concept mapping technique in describing themselves and their perceptions. Therefore, it is always suggested to triangulate the data collected through concept mapping.

This study has described a novel qualitative analyzing method for concept maps through a part of a bigger study. Qualitative methods demonstrated that concept maps provide deep information which has been started to be revealed efficiently. It also assured that there is not only one way to create and analyse concept maps in order to obtain the information as precise as possible. Therefore, when the aim is to gain deeper information, there is always a need for studies exploring the different techniques of creating and analysing concept maps as well as the other research instruments and tools.

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