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Assessment of Concept Maps Generated by Undergraduate Students about the Function Concept

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Abstract

This research aims to assess the concept maps related to the function concept generated by undergraduate students. In our study, firstly students were asked to write down the concepts that they know about the functions then generate a concept map by using these concepts. After this application a five-item questionnaire was also applied in order to get students' opinions about concept maps. The maps generated by students were analyzed according to the systematic of Varghese (2009) and the answers to the questionnaire were separately examined. It was observed from the findings that the students had difficulties in generating concept maps and relating the function concept with the other concepts.

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1. Introduction

Concept knowledge is not only identifying or knowing the definition of the concept but at the same time, it is the ability to see relationships and transitions between concepts. A single concept does not mean anything. The meaning related with the concept occurs if the concept is related with the group that has the meaning of the so called concept. Whenever the new information can be associated and accommodated with the previous one properly, the meaning about this concept occurs (Soylu and Aydın, 2006).

Function is among the major concepts of mathematics with a variety of its presentation and interpretation. It is still a difficult concept for students to understand although attention is paid to teach it with multiple representations and much time is spent to teach it (Sajka, 2003). In the standards of National Council of Teachers of Mathematics (NCTM) (1989,1991,2000), it is emphasized that function subject should take an important place at the mathematics curriculum and it helps students to understand other subjects and to create relations among different mathematics subjects. According to Oehrtman, Carlson and Thompson (2008), the concept of function is at the center of undergraduate mathematics and full understanding of this subject is necessary for the calculus course which is a critique one for the progress of future scientists, mathematicians and engineers.

In order to recognize that mathematics is composed of interrelated concepts and patterns, and to reflect these relationships, metacognitive tools which will ensure meaningful learning are needed. One of these metacognitive tools is concept maps.

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Novak and Gowin (1984) in their studies regarding ‘learning how to learn’ indicated that concept maps can be used to help students to learn, to help teachers to organize teaching materials and to resolve misunderstandings about the concepts. Using concept maps for evaluating the organization of the mathematical knowledge occurred by the model which was developed by Hiebert and Carpenter (1992) for analyzing meaningful mathematical learning and learning activities.

Concept maps have been used by many researchers to assess the mathematical knowledge of the students. Some of the studies carried out at undergraduate level are the following: Afamasaga – Fuatai (2004) investigated an undergraduate student’s understanding of differential equations with progressive concept map technique. Varghese (2009) gave 24 concepts to student teachers about the proof to analyze their understandings of the mathematical proof and to assess concept maps which they created by using these concepts.

2. Method

This study was carried out during the spring semester of 2011 with the participation of freshmen. Study group, data collection instruments, and data analysis are explained in detail below.

2.1. The Aim of the Study

The aim of this study is to assess the concept maps concerning the concept of functions which were generated by freshmen studying at different departments of an engineering faculty. Within the framework of this aim, the answers of the following questions were searched: ‘Which concepts do students know related to the function concept?’ and ‘What kind of concept maps can students create by using the concepts they know about the function concept?’.

2.2. Study Group

The participants are 13 freshmen studying in an engineering faculty of a private university in Konya. Two of these students are female and eleven of them are male. Regarding the importance of mathematical thinking during engineering education and since students frequently use mathematics in other courses other than mathematics; students of the study group were selected from engineering students who were eager to participate.

2.3. Data Collection

By considering primary and secondary school programs, it is thought that students are familiar with concept maps and a reminding presentation about concept maps was given to students during a period of 45 minutes and sample concept maps, from simple to complex, were shown to students at the beginning.

In various studies, it is seen that researchers use different methods to generate concept maps such as *collaborative concept mapping*, *producing concept maps by filling in the blanks*, *concept mapping from scratch* and *flow map method* (Anderson and Demetrius, 1993; RuizPrimo, Schultz, Li and Shavelson, 2001; Varghese, 2009).

In our study, method of *concept mapping from scratch* was used. In this method, either it is expected from students to use a number of concepts given to them to produce maps or they are asked to produce their own maps by using concepts that they selected among a few major concepts (Şen and Özgün-Koca, 2003). According to this approach, a ‘Practicing Concept Maps Form’ which was composed of two parts was given to students. In the first part of the form, students were asked to write terms/concepts that they know about functions and in the second part, they were asked to generate a concept map by using these concepts in a period of 45 minutes. After this practice, in order to learn students’ opinions about concept maps, ‘Opinion Survey about Concept Maps’ which consisted of five questions was applied.

2.4. Data Analysis

In this study, the data collected through the *concept map form* and the *opinion survey* were evaluated both by qualitative and quantitative methods. The concept maps created by students were analyzed qualitatively without giving any scores, according to Varghese's (2009) systematic under the following headings of; i) the number of terms/concepts listed by students in the first part of the concept map form, ii) the number of concepts used in the concept maps, iii) the number of propositions used in concept maps, iv) usage of symbols and examples in concept maps, v) concepts used by students other than the concepts listed in the first part of the form.

3. Findings and Interpretations

The students listed totally 41 different terms/concepts in the first part of the 'Practicing Concept Maps Form'. 'Polynomial function' is the most used term while 'variable' is the least used term by the students. Table 1. provides a summary of our observations about the different forms of concept maps generated by the students.

Table 1. Observations from concept maps

| Student | # of terms listed in part I | # of terms used in the map | # of propositions used in the map | Symbols and examples used | Terms outside the list used |
|---------|-----------------------------|----------------------------|-----------------------------------|---------------------------|--|
| 1 | 14 | 14 | 0 | No | - |
| 2 | 23 | 28 | 1 | Yes | Increasing and decreasing function, critical point, definite integral, Cartesian and polar coordinates |
| 3 | 15 | 13 | 0 | No | integral, maximum and minimum values, inflection point |
| 4 | 15 | 15 | 1 | Yes | slope, increasing, decreasing, definite integral, inflection point |
| 5 | 8 | 7 | 0 | No | - |
| 6 | 16 | 17 | 0 | Yes | real numbers, increasing, decreasing |
| 7 | 11 | 16 | 2 | Yes | real numbers, increasing and decreasing function, integral, ekstremum, inflection point, logarithmic and trigonometric function |
| 8 | 17 | 16 | 0 | Yes | polynomial, exponential, logarithmic and trigonometric function |
| 9 | 14 | 14 | 4 | Yes | increasing, decreasing |
| 10 | 20 | 20 | 20 | Yes | multiple integral, directed derivative |
| 11 | 16 | 17 | 0 | Yes | real numbers |
| 12 | 13 | 23 | 2 | Yes | real numbers, exponential and logarithmic function, inflection point, partial derivative, graph of function, coordinate system, Cartesian, polar and spherical coordinates |
| 13 | 17 | 25 | 1 | Yes | slope, tangent, critical point, graph of function, spherical coordinates, exponential and logarithmic function, local maximum and minimum |

Students who participated in the study were indicated in the table by the numbers. It cannot be said that any of the students created a highly organized concept map. In addition to that, it was seen that best maps were created by successful students. A similar situation can also be seen at Varghese's (2009) study. Especially the structures which were produced by S1 and S5 were not suitable to the structure of concept maps but they were included in Table 1 to display the number of concepts used by these students.

It was observed that the concept maps used by students in this study were generally in tree or hierarchical types. An example of a concept map generated by the students is given in Figure 1. Students except S1 and S5 wrote the concepts in oval or rectangular boxes. All the students used lines or arrows to relate the concepts.

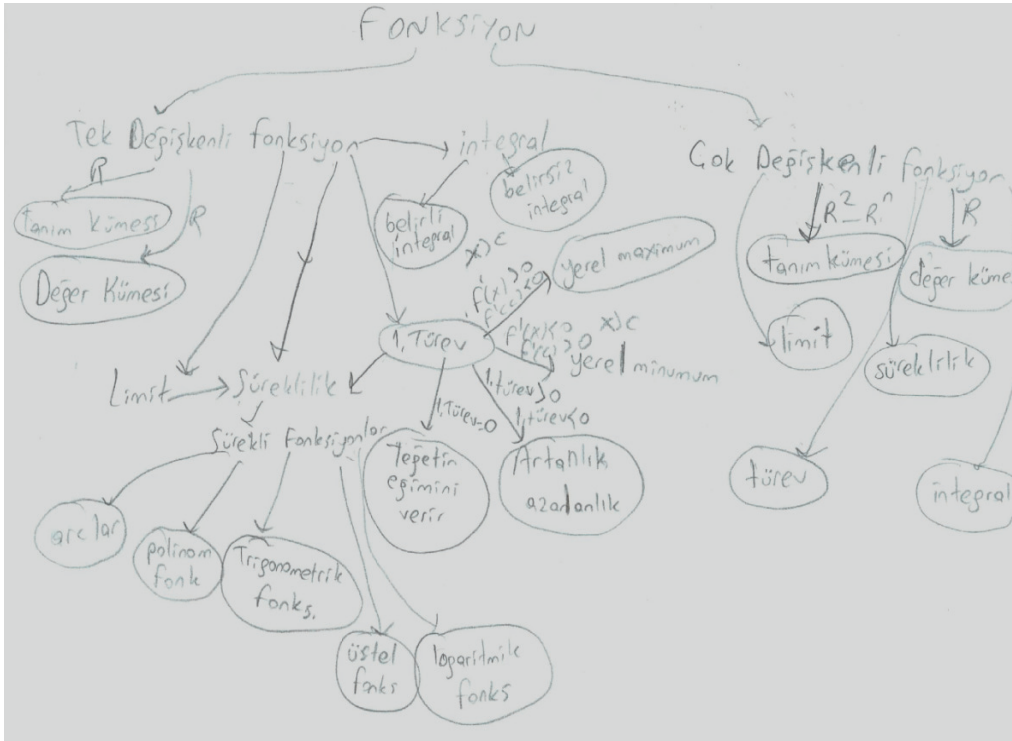


Figure 1. An example of a concept map generated by the students.

The basic element of a concept map is a proposition consisting of two concepts connected by linking words which shows the relation between the concepts (Varghese, 2009). Only 7 students used propositions to relate the concepts. It can be said that students have difficulties in relating the concepts as the number of propositions used in the concept maps are less. Novak and Canas (2008) express this situation as follows: 'Students often have difficulties in adding associative expressions on arrows or lines in their concept maps. The reason of this difficulty comes from the lack of understanding of the concepts or relations between concepts. In fact, focusing on propositions and cross-links enable students to see how much a concept is related with the others and this consists of high level cognitive performances such as evaluation and synthesizing knowledge as it was stated in Bloom (1956)'.

Only ten students used examples and symbols in their concept maps while three of the students did not use any examples or symbols. Since the number of examples used by students in the concept maps are very few and some of them are also incorrect and partly from unrelated concepts, we can say that students cannot fully structure the concepts.

Analysis of the answers of students to the "Opinion Survey about Concept Maps" was demonstrated in Table 2.

Table 2. Opinion survey and answers given by the students

| | | Yes | No |
|---|--|-----------|---------|
| 1 | Did you have any prior information about concept maps? | 9 (69%) | 4 (31%) |
| 2 | Did you use concept maps in any of your lessons before? | 11 (85%) | 2 (15%) |
| 3 | Is the use of concept maps beneficial in teaching engineering? | 13 (100%) | 0 (0%) |
| 4 | Do you want to use concept maps to evaluate conceptual learning of students? | 11 (85%) | 2 (15%) |
| 5 | Is the information given before the study about the concept maps sufficient? | 12 (92%) | 1 (8%) |

4. Results and Suggestions

A large number of incorrect connections in concept maps and the lack of associative expressions between concepts can be accepted as an indicator that conceptual learning does not occur. In addition to this, because of the lack of the usage of appropriate examples and symbols in concept maps, we can infer that students' abstraction of the concept of function is insufficient in their minds. From the answers provided for the survey, it is seen that using concept maps in lessons will be beneficial in terms of education.

According to the results of this study, it can be suggested that concept maps as the graphical and clear presentation of knowledge should be used more actively in the process of constructing information starting from primary schools, for the realization of conceptual learning. Also, concepts maps should be used especially in mathematics lessons to display strong structures existing between concepts. Moreover, it will be beneficial to encourage students to adapt concept maps into various learning situations and give more time to students to produce concept maps.

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