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PROSPECTIVE CHEMISTRY TEACHERS' ABILITIES OF CREATING CONCEPT MAPS: HYDROCARBONS EXAMPLE

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Abstract. *Concept maps are effective tools for showing the relations between the concepts and they can be used to make clear the relations between the abstract concepts such as hydrocarbons topic. The aim of this research is to determine the abilities of prospective chemistry teachers' (PCTs) creating concept maps about hydrocarbons. In this research , case study was used and the study was carried out in a university in North Coast of Turkey with 25 PCTs (aged 20-27). PCTs were taught how to create concept maps, types of concept maps such as hierarchical, non- hierarchical and chain or spoke concept maps through example concept maps. In this research context, PCTs were given a text about hydrocarbons and they were supposed to prepare their own concept maps about hydrocarbons. Their concept maps were evaluated according to the reference concept map which was prepared by the researchers. At the end of the research, it is seen that PCTs had difficulty in constructing concept maps. According to the conclusions drawn from the research, some suggestions were offered.*

Key words: *concept maps, conceptual learning, hydrocarbons, organic chemistry, prospective chemistry teachers.*

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Introduction

Science/chemistry educators have recently focused their efforts on issues of conceptual teaching. The reason for being important of conceptual change is that while students have the ability to solve difficult science problems, they often fail to learn the fundamental science concepts (Masson & Vazquez-Abad, 2006; Case & Fraser, 1999). Then, different learning approaches (constructivism, context-based approach, etc.), different learning methods and techniques (concept maps, concept cartoons, predict-observe-explain, worksheets, etc.) are used to provide conceptual learning and remedy alternative conceptions (for example Dönmez Usta, 2011; Bak Kibar, Yaman & Ayas, 2013; Ültay, 2012; Ültay, 2015; Dönmez Usta & Durukan, 2015) because traditional instruction is not sufficient to promote conceptual change (Bodner, 1991; Harrison & Treagust, 2001; Hewson, 1992; Hewson & Hewson, 2003). Constructivism and context-based approach which is built upon constructivism (Berns & Erickson, 2001; Crawford, 2001; Glynn & Koballa, 2005; Imel, 2000; Lynch & Padilla, 2000) are based on that every learner constructs his/her own knowledge by linking the new knowledge with existing knowledge (Driver & Easley, 1978; Driver, 1981; Sendur & Toprak, 2013; Ültay & Ültay, 2014). In this research, we attempt an impersonal style should be used to address creating concept maps which help students integrate new knowledge and build upon their existing naïve concepts (Kinchin, Hay & Adams, 2000).

Concept maps, which are used to remedy alternative conceptions in conceptual learning are graphical tools for showing the organization of knowledge. They include concepts shown in circles or boxes, and relationships between concepts indicated by a connecting line linking two concepts. Words on the line referred to as linking words or linking phrases, specify the relationship between the two concepts (Novak & Cañas, 2008). Two concepts and the linking word that show the relationship between two concepts should form a meaningful statement. Concept maps also include cross links other than concepts and linking words. Cross links show the relationships between the concepts, existing in different domains or segments of the concept map.

Concept maps were firstly developed by Novak in 1972 and shown as a classroom technique that enhanced science learning. According to McClure, Sonak and Suen (1999) concept maps can be used as a learning strategy, as an instructional strategy, as a strategy for planning curriculum, and as a means of assessing students' understanding of science concepts. No matter they are prepared for whatever reason, it is useful and advantageous because it is dynamic and visual in science/chemistry learning. Researchers have shown that concept maps are effective tools for assessment to elicit and enhance students' conceptual understanding (Novak & Gowin, 1984; White & Gunstone, 1992). The results of the studies showed that using concept maps in classrooms helped students to link the concepts and reduced their alternative concepts related to the topic (Özmen, Demircioğlu, Coll, 2009). Therefore, teachers can use concept maps in their courses for different purposes. In this research, abilities of PCTs' creating concept maps about hydrocarbons are discovered. If we expect that PCTs use concept maps in their classrooms, firstly they should know how to prepare concept maps. In this research, PCTs tried to create concept maps about hydrocarbons.

Hydrocarbons topic is a part of organic chemistry course. As Johnstone (1974) and Sendur and Toprak (2013a) reported in their studies, students stated that organic chemistry was one of the most difficult areas in chemistry. Similarly, Fensham and George (1973) investigated problems arising from the learning of organic chemistry while Kellett and Johnstone (1974) indicated that students had little conceptual understanding of functional groups and their roles. Furthermore, in Turkey, organic chemistry has a vital role in university entrance exams because there are many questions seeking to understand organic chemistry. On the other hand, only a few studies focusing on organic chemistry have been conducted (Sendur & Toprak, 2013). However, organic chemistry has occupied an extremely large area in our lives from plastics and perfumes to human body (Petrucci, 1989). Because of these reasons, it is necessary for a teacher to think and create alternative teaching methods and techniques for difficult topics and then they should use alternative assessment methods. From this point, the purpose of this research is to determine the abilities of PCTs' creating concept maps about hydrocarbons.

Methodology of Research

In this part, methodology of research is explained. Method of research and sample, implementation and data collection process and data analysis are explained respectively in the following.

Method of Research and Sample

In this research, case study was used because this research method gave opportunity to investigate the properties of a sample group deeply (Creswell, Plano Clark, Gutmann & Hanson, 2003). The research was carried out in a university in North Coast of Turkey with 25 PCTs (aged 20-27; 10 males and 15 females). PCTs are represented as PCT1, PCT2, PCT3, …, PCT25 in the research.

PCTs in the sample group were graduated from Chemistry Department of Science Faculties with a bachelor's degree before. Then, because PCTs wanted to become a chemistry teacher, they had to complete a pedagogical formation program successfully in Turkey. Pedagogical formation program, which was organized by the Education Faculties of universities, lasts two semesters and in the first semester there are some educational courses such as Introduction to Education, Classroom Management, Educational Psychology, Principles and Methods in Instruction, Assessment and Evaluation of Learning in Chemistry; in the second semester there are Instructional Technology and Material Development, Practice Teaching in Chemistry, Teaching Methods in Chemistry. After completing the program successfully, they enter an exam and will be assigned as a teacher according to priority of scores got from the exam. Apart from this, in Turkey there are Education Faculties which train teachers and during 4 years prospective teachers take in pedagogical formation courses and content area courses together in these faculties. Then they enter the same exam and will be assigned as a teacher, according to priority of scores got from the exam. Graduate students of Education Faculties had already been interested in chemistry education courses during their training, so they were more used to creating concept maps, but graduate students of the Science Faculties had firstly performed creating a concept map in the pedagogical formation program.

The first researcher asked the PCTs about their willingness to participate in the research. She assured the PCTs that they were not obliged to participate in the research and that they would not be awarded extra points for their participation. The consent of the participants was requested before their responses in the implementation were shared with the reader. Before and after the implementation, some of the dialogue between the researchers and the participants were not reflected in the research and remained between the two because of the principles of privacy and confidentiality. The participants willingly participated in the research.

Implementation and Data Collection Process

While PCTs were studying Instructional Technology and Material Development course, they were taught how to create concept maps, types of concept maps such as hierarchical, non- hierarchical and chain or spoke concept maps through example concept maps for 2 weeks and 4 class hours (4*50 minutes) by the first researcher. In addition, they were also taught how to create concept maps through different approaches and were informed about the critical points of creating concept maps. After that, PCTs were given an example text and they prepared their concept maps and they were discussed in detail in the class. In this research context, PCTs were given hydrocarbons text and they were supposed to prepare their own concept maps about hydrocarbons by using the concepts in the text.

The reason of giving a text for creating a concept map is seen as necessary for this participating group because this group studied some chemistry education courses only in pedagogical program and they graduated from the chemistry department of universities. This reveals that although participators knew some theoretical knowledge about organic chemistry and hydrocarbons, they had no idea about creating a concept map. To overcome this weakness of the research, researchers firstly tried to teach how to create a concept map and then they prepared a hydrocarbon text to make easier their creating concept maps. Hydrocarbons text is given in the following:

HYDROCARBONS

> Hydrocarbons are divided into two: aliphatic and aromatic hydrocarbons. Aliphatic hydrocarbons have chain or cyclic structure. Aliphatic hydrocarbons are divided into saturated and unsaturated. Alkanes are the examples of saturated aliphatic hydrocarbons. Alkanes are apolar compounds. General formula of alkanes is C_nH_{2n+2}. The simplest member of alkanes is methane (CH_4). Alkanes can be obtained through Wurtz synthesis and Grignard compounds. Alkanes are widely used in natural gas, asphalt, petroleum and LPG. Alkenes and alkynes are the examples of unsaturated aliphatic hydrocarbons. The simplest member of alkenes is ethylene (C_2H_4). General formula of alkenes is C_nH_{2n}. Alkenes have cis- and trans- isomers. Alkenes can be obtained by adding one mole H_2 to alkynes. Alkenes are widely used in the synthesis of polymer compounds such as PVC, polyethleyene and Teflon. The simplest member of alkynes is acetylene (C_2H_2). General formula of alkynes is C_nH_{2n-2}. Alkenes and alkynes give polymerization reactions. Alkynes are widely used in welding and lighting. Aromatic hydrocarbons are arenes. Benzene (C_6H_6) and its derivatives are aromatic hydrocarbons. Aromatic hydrocarbons are largely obtained from petroleum and coal. Aromatic hydrocarbons are widely used in thinner, WC deodorants, resin, moth protective and dye industries.

Data Analysis

There are three different approaches for evaluating the concept maps (Kaya, 2003). The first of all is to evaluate the content of the concept maps (White & Gunstone, 1992). In this evaluation approach, four criteria are determined such as propositions (1 point), hierarchy (5 points), cross links (10 points) and examples (1 point) (Kaya, 2003; Bak & Ayas, 2008). In the second approach, an expert or a teacher creates the concept map and this concept map is evaluated with the first approach's criteria. Then the students' concept map is compared to the expert's concept map. The third approach is the combination of the first two approaches. Firstly, an expert or a teacher creates the concept map (it can be called as reference concept map) and his/her concept map is evaluated and scored with the criteria in the first approach. Then the score of the students' concept map is calculated by dividing it to the reference concept map's total score (Bak & Ayas, 2008). The reference concept map is prepared by the researchers and it is given in Figure 1.

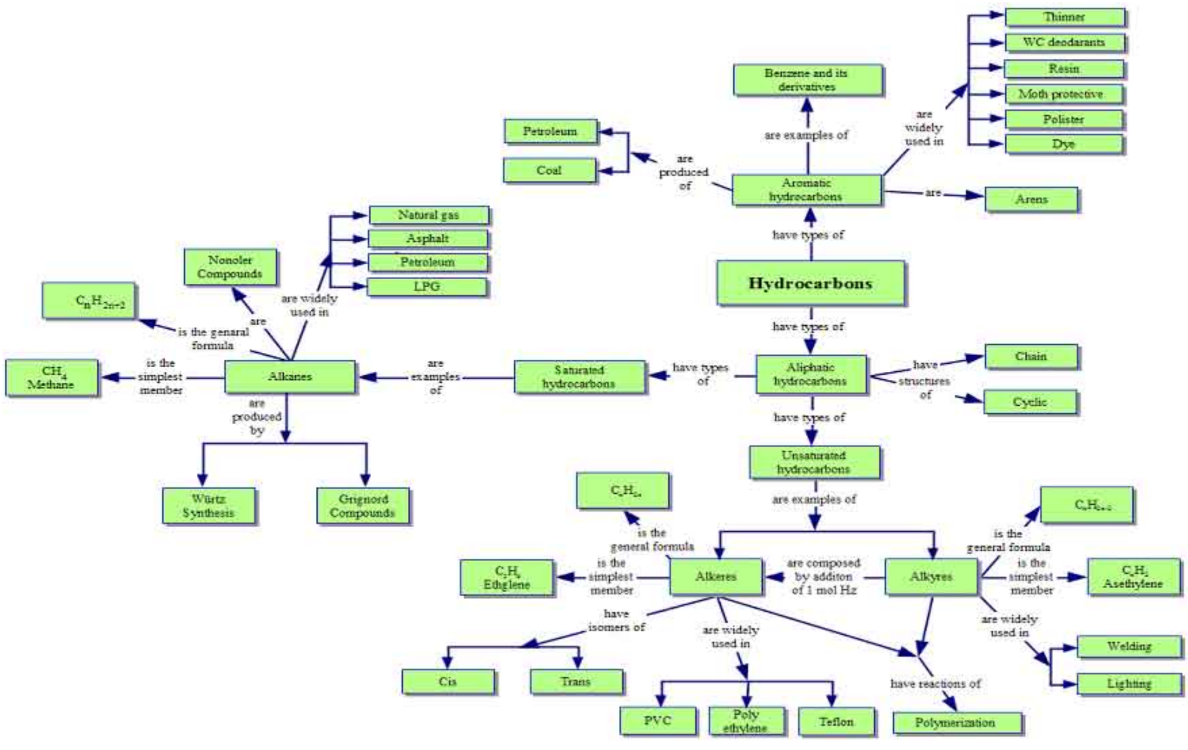

Figure 1: **Reference concept map.**

There are some types of concept maps such as hierarchical, non-hierarchical, chain or spoke (Novak & Gowin, 1984). In this reference, concept map, chain concept map is formed and PCTs' concept maps are evaluated according to the reference map in this research, after reading the hydrocarbons text, it was suitable to create a chain concept map because of the concepts in the text.

Validity and Reliability

In this research, to ensure the hydrocarbon test valid, a chemist and two chemistry educators had read it and they ensured the text's readability, appearance and content validity. Some minor changes were done after their valuable comments. To evaluate the PCTs' concept maps, a chemistry educator different from the researchers of this research scored the concept maps and the interrater reliability coefficient (Cohen's Kappa) between the researchers and the chemistry educator was found to be 0.81. Overall, these procedures have been done to ensure the research validity and reliability.

Results of Research

In this part, the data obtained from the PCTs' concept maps were analyzed based on the third approach stated in the data analysis part and they were quantitatively evaluated in terms of criteria defined in the first approach such as valid concept number, hierarchy step, accurate relation, cross link number and examples. Then the PCTs' concept maps were compared to the reference concept map prepared by the researchers. Quantitative analysis of the PCT's concept maps is given in Table 1.

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Table 1. Quantitative analysis of the PCTs' concept maps.

Max. T.S.	V.C.N.	P.	H.S.N.	P	A.R.N.	P.	C.L.S.	P.	E.N.	P.	T.S.	TS100
	40	40	40	200	41	41	2	4	3	3	285	100
PCT1	26	26	31	155	31	31	-	-	3	3	215	75,43
PCT2	1	1	10	50	10	10	-	-	3	3	64	22,45
PCT3	16	16	16	80	16	16	-	-	3	3	115	40,35
PCT4	13	13	13	65	13	13	-	-	3	3	94	32,98
PCT5	23	23	28	140	28	28	-	-	2	2	193	67,71
PCT6	27	27	31	155	31	31	-	-	2	2	215	75,43
PCT7	17	17	19	95	19	19	1	2	3	3	136	47,71
PCT8	7	7	15	75	15	15	1	2	2	2	100	35,08
PCT9	13	13	26	130	26	26	1	2	2	2	172	67,36
PCT10	15	15	8	40	8	8	-	-	-	-	63	22,10
PCT11	29	29	39	195	34	34	2	4	2	2	264	92,63
PCT12	18	18	24	120	24	24	1	2	2	2	166	58,24
PCT13	18	18	14	70	14	14	2	4	2	2	108	37,89
PCT14	18	18	14	70	14	14	1	2	2	2	106	37,19
PCT15	16	16	24	120	24	24	1	2	3	3	165	57,89
PCT16	12	12	15	75	15	15	-	-	3	3	105	36,84
PCT17	14	14	16	80	16	16	-	-	3	3	113	39,64
PCT18	16	16	17	85	17	17	1	2	2	2	122	42,80
PCT19	16	16	23	115	23	23	1	2	2	2	158	55,43
PCT20	13	13	16	80	16	16	-	-	3	3	112	39,29
PCT21	16	16	19	95	19	19	1	2	3	3	135	47,36
PCT22	7	7	9	45	9	9	-	-	2	2	63	22,10
PCT23	12	12	20	100	20	20	-	-	2	2	134	47,01
PCT24	21	21	32	160	29	29	-	-	2	2	212	74,38
PCT25	17	17	28	140	21	21	-	-	2	2	180	63,15

Max. T.S.: Maximum total score of the reference concept map, V.C.N.: Valid concepts's number, H.S.N.: Hierarchical Step's Number, A.R.N.: Accurate Relations's Number, C.L.N.: Cross Links Number, E.N.: Examples's Number, T.S.: Total Score. T.S100.: Total Score out of 100.

As seen in Table 1, while 40 valid concepts were formed by the researchers, PCTs could have formed from 1 to 29 concepts varying from PCT to PCT. While hierarchical step numbers of the researchers were 40 in the reference concept map, it is seen that hierarchical step numbers of PCTs varied between 8 and 39. Also, while 91 accurate relations were defined by the researchers, accurate relations, varying between 8 and 34 were defined by PCTs. While 2 cross links were formed by the researchers, no cross links were formed by most of PCTs. Additionally, in the hydrocarbons text, 3 examples existed and PCTs also formed 2 or 3 examples. It is seen that total scores that PCTs got in terms of the criteria stated in Table 1 varied between 63 and 264 and these scores varied in a wide range between 22,10 and 92,63 at 100 points grading system. PCT11's concept map which gave the maximum score among PCTs' concept maps is shown in Figure 2.

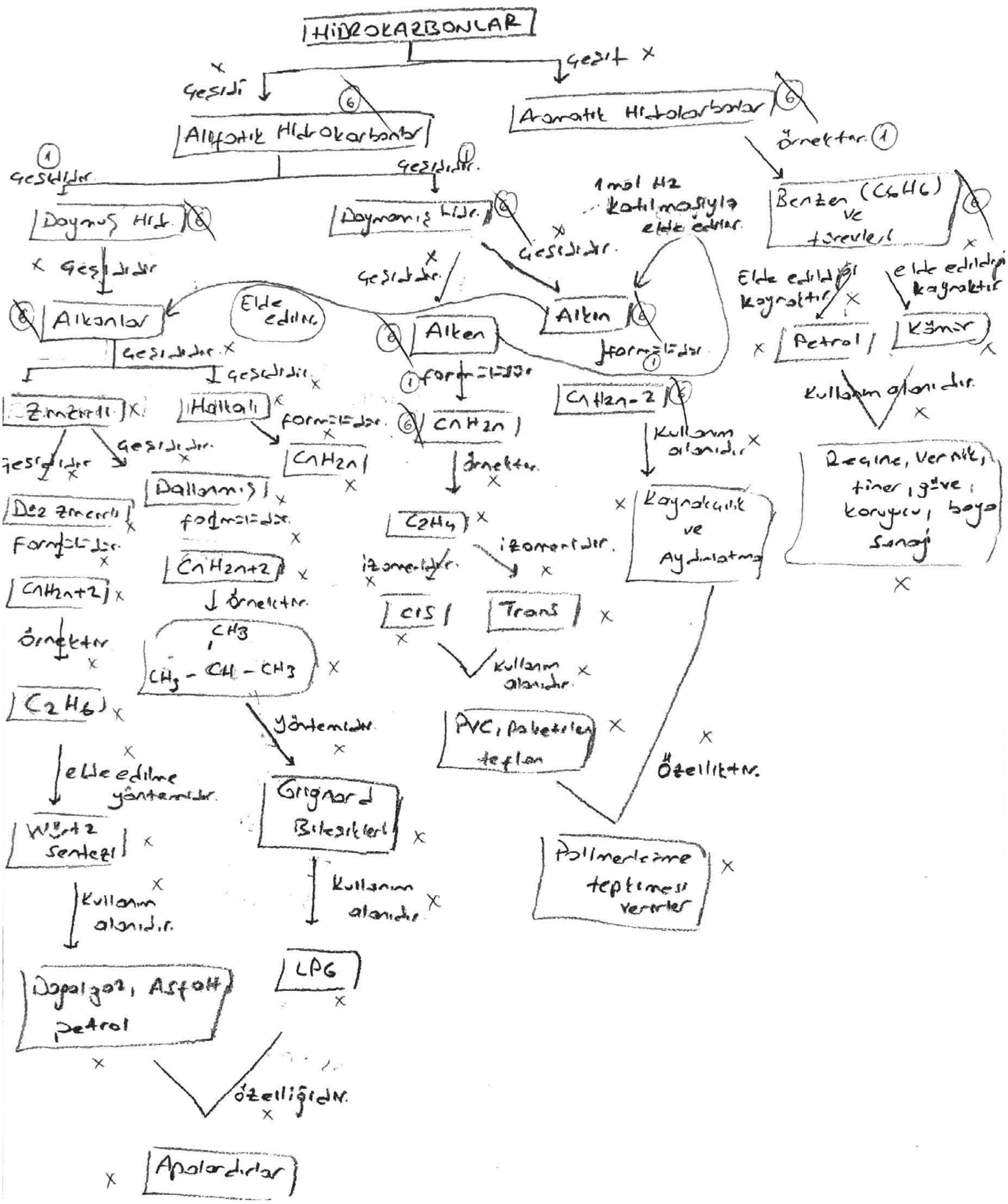

Figure 2: PCT11's concept map which has the maximum score.

An example concept map (PCT2) which gave one of the lowest scores is given in Figure 3.

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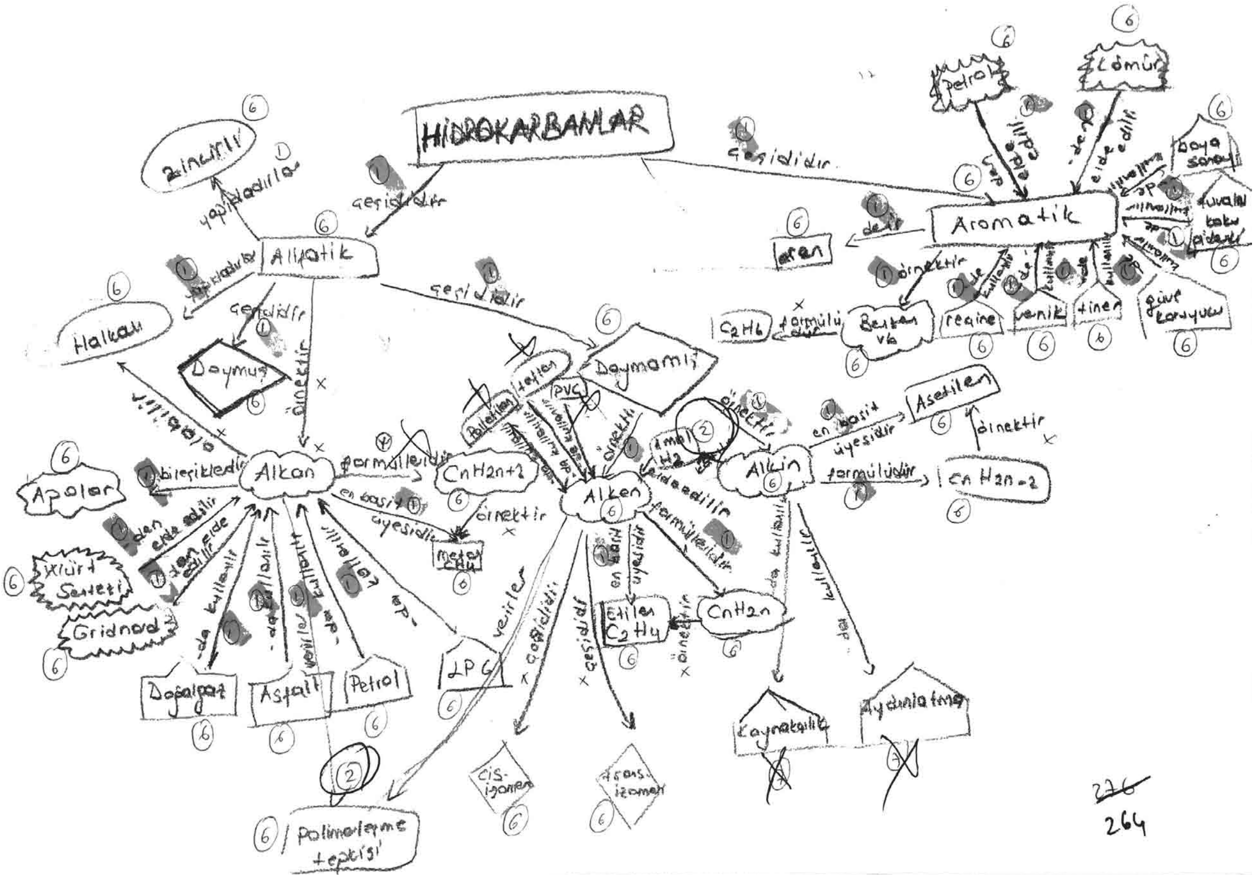

Figure 3: PCT2's concept map which has one of the lowest scores.

While 40 valid concepts were formed by the researchers in the reference concept map about the ''Hydrocarbons" text, it is surprising that maximum 29 valid concepts were formed by PCTs. This makes us to think that PCTs had difficulty in determining the "concepts" among the other words in the given text.

Discussion

When concept maps formed by PCTs are considered as a whole, it may be said that PCTs had difficulty in finding most of the general concepts, forming the hierarchical steps, establishing accurate relations and cross links. In Sahin's (2001) research which were carried out with prospective teachers, it was stated that the hardest point of forming a concept map was constructing hierarchical steps and the second hardest point was forming lateral relations (cross links) (Mintzes, Wandersee & Novak, 1997; Novak, 1998). In this research, the reason of PCTs' had difficulty in establishing hierarchical and cross links can be that PCTs may have not enough content knowledge. Namely, the first stage of forming a concept map is to be able to establish hierarchical structure. It may be related to the lack of content knowledge of PCTs in hydrocarbons.

There are many alternative conceptions relevant to the concepts of alkane, alkene, and alkynes in hydrocarbons as stated in the literature (Sendur, 2012; Sendur & Toprak, 2013b) because hydrocarbons topic which takes place among the organic chemistry course includes abstract concepts. Within this context, it may be stated that alternative concepts which PCTs have may adversely affect forming the concept map, even if a text is given. In the literature, it was stated that one of the main objectives of the science training is to make the students gain concepts and establish relations between these concepts (Ayas, 2005). This situation points out that using concept maps within the learning - teaching process has great importance. Using the concept maps within the aim of assessment as well as using in the learning-teaching process (Vanides, Yin, Tomita & Ruiz-Primo, 2005) helps to detect the alternative concepts. In this research, it is thought that alternative concepts that PCTs have may have played a role in establishing the relations between the concepts because PCTs may have structured the concepts by comparing them with the concepts that they have already had at their minds. It may be explained with the alternative concepts that PCTs already had, were resistant to change because PCTs had difficulty in establishing the relations between the concepts (Berquest & Heikkien, 1990). Also, it does not seem possible to correlate with PCTs' had difficulty in establishing the relations between the concepts with lack of knowledge even if the text is given. As stated in the research of Aktaş and Güler (2012), it may be explained that PCTs may have had difficulty in establishing relations rather than lack of content knowledge.

As can be seen in Table 1, most of PCTs accurately placed the examples. This situation may be related with using explicitly the exact expression of "example" in the hydrocarbons text. Also, this shows that using clear expressions in the given texts helps the PCTs to establish accurate relations while creating the concept map. Furthermore, when it is thought that concept maps allow for the PCTs visualizing the relations between the key concepts through a systematic way in terms of thinking the relations between learned science concepts and reflecting their own meanings with the arrangement of the thoughts (Vanides *et al.*, 2005), there will not be need for giving the statements or expressions explicitly for the ones who have enough field information concerning the relevant subject. This situation reveals that PCTs have not enough content knowledge in hydrocarbons. Also, because PCTs took Organic Chemistry course in previous years, they may have forgotten the hydrocarbons subject.

When concept maps of PCTs are reviewed, it is seen that they had difficulty in structuring the concept map as well as establishing relations and cross links. The reason may be explained with PCTs had not enough experience regarding establishing concept maps. This situation may also be stated at some studies in the literature (Aktaş & Güler, 2012). Students may not be successful in the first or second time they create a concept map.

Conclusions and Recommendations

The research findings reported here suggest that PCTs had difficulty in constructing concept maps about hydrocarbons. Although PCTs were taught how to create a concept map during four lesson hours and they performed an example concept map about a different topic, it may not have been enough for them. In this case, it is suggested for PCTs creating a concept map on their own in the relevant courses such as Teaching Methods in Chemistry and Instructional Technology and Material Development after making example applications concerning how PCTs will construct the concept maps.

PCTs are found insufficient at establishing the concepts in proper/right places or levels. It can be said, that PCTs' conceptual development about hydrocarbons is not sufficient to create concept maps. Because the concepts in hydrocarbons are mostly abstract, it can be suggested that alternative teaching methods (concept cartoons, constructed grids, conceptual change texts, etc.) can be integrated into the lessons to show the conceptual relations more clear. Teachers can get benefit from the concept maps which are one of the alternative assessment and evaluation methods. It can be recommended to use concept maps as an assessment and evaluation technique when it is thought that concept maps allow for not only understanding how abstract concepts are structured cognitively, but also provide an alternative assessment environment for the teachers regarding the use of different teaching methods and techniques before and after learning.

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