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Examining High School Students' Cognitive Structures on the Concept of Cleaning Agent through Word Association Test

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Abstract

The aim of this research is to determine high school students' cognitive structure regarding cleaning agent via word association test. The sample of the research consists of 160 high school students. A word association test (WAT) prepared to test the structure addressed in the study was used as the data collection tool. Content analysis was used to evaluate the data obtained from the sample group. Words written by high school students in relation to the test were analyzed elaborately and based on this analysis concepts were categorized as well as their frequency. As for the first section of the word association test, three main categories were obtained: Chemical cleaning agent, natural cleaning agent, and cleaning equipment. When it comes to the second part, the highest frequency values were in the category of chemical cleaning agent, natural cleaning agent category, cleaning equipment category. All in all, it was concluded that the natural cleaning agent category had the highest frequency, the chemical cleaning agent category was in the second place, and the cleaning equipment category had the lowest frequency.

Keywords: Cleaning Agent, Chemistry, High School Students, Word Association Test (WAT)

INTRODUCTION

Chemicals are used not only in the industrial sector, but also in our daily lives like cleaning, disinfection, personal care, etc. Considering the fact that they are used in many facet of life, individuals should be informed about the effects of these chemicals that we use for cleaning, hygiene and maintenance on health and the environment within the scope of chemistry courses. Likewise, chemistry courses provide information about the hazards of excessive use of chemicals in everyday life for both human beings and nature (MONE, 2018). Chemistry educators should know that chemistry is a difficult field for students to understand (Rüschenpöhler & Markic, 2020). Educators should enable students to overcome this prejudice with appropriate activities (Gegios et al., 2017), and in this way, students can be made to realize that chemistry is understandable and applicable (Mujtaba et al., 2020). While doing the activities, students should be prevented from following the procedures without thinking or understanding (DeKorver & Towns, 2015). It should be emphasized that students combine theoretical knowledge with experimental work (Guerrero et al., 2016). In order to be informed about chemicals that will harm human health and the environment, parallel subjects should be determined in high school chemistry course as well as other courses and environmental awareness of individuals should be improved (Şahin, et al., 2004). Many substances such as detergents, cleaning products, stain remover chemicals are used unknowingly to obtain cleaner surfaces (Karapınar, 2015; URL-1; URL-2).

It bears crucial importance to educate people as environment friendly in order to live in a healthy and clean atmosphere and of course to leave a habitable place for future generations (Erol & Gezer, 2006). To achieve this goal, teachers should draw students' attentions on such issues as the consequences of insensible use of natural sources, the necessity of recycling, the effect of environmental pollution on nature and all living creatures (Bahar & Kiras, 2017). Similarly, the use of cleaning agents, essential for human health and nature, is concerning everyday life (Elmas & Geban, 2016) and therefore should be included in environment education.

The cleaning cycle begins with the material produced during the contamination cycle. The need for education to minimize the environmental impact of cleaning, accurate monitoring, and assurance is common to all (Wilson, 2005). Exposure

to chemicals occurs in the workplace (Hellweg et al., 2005), during chemistry and food production (Avila-Sierra, et al., 2021). Since the use of each new chemical will create new problems, we should not forget that chemicals in our lives can have disadvantages as well as beneficial effects (Antonsson, 1995). There is a wide range of soaps, detergents, bleaches, fabric softeners, polishes and specialty cleaners for bathrooms, windows, drains and ovens that keep our homes clean and fragrant. The chemicals in these cleaners lather, bleach and disinfect our dishes, laundry, bathrooms and countertops. They also contribute to indoor air pollution, are toxic if swallowed and can be harmful if inhaled or touched (Jyotie, 2015). Cleaning agents are obtained from petroleum derivatives, which are unnatural. We are exposed to these chemical-containing substances through the respiratory tract, skin and digestive system. Active substances in detergents damage the barrier of human skin. The structure of the skin is affected, as a result of which pests such as microbes and allergens reach the tissues more easily (Akdiş, 2019).

The waste of cleaning agents' mixes into rivers through the sewage system, reaching the lakes and even the sea, polluting the water resources. Since cleaning agents are unnatural substances obtained from petroleum derivatives, they are very durable. Thus, the rate of fragmentation in nature is very slow. These substances, which remain in nature for a long time, can even mix with drinking water over time. Biochemical changes and metabolic disorders occur in living things exposed to water contaminated by cleaning agents (Ayaz & Yurttagül, 2008). Cleaning products cause skin problems (Alfonso, et al., 2015), household cleaning products increase the risk of cancer (Zota, et al., 2010), and cause asthma (Weinmann, et al., 2017; Le Moual, et al., 2012). Despite all these negative effects, cleaning products are expected to offer features such as good cleaning performance, reasonable price, environmentally friendly, pleasant smell, consumer safety (Hauthal & Wagner, 2004). It is generally stated that students emphasize safety issues and environmental themes related to cleaning agents (Aulanko, 2007). To reduce the impact of substances such as soap and detergent on the environment, sewage treatment plants must function very smoothly (Jaworska, et al., 2002).

Today, the subject of cleaning agents, which is the subject of many news, has an important place both in terms of health and environmental awareness. Different cleaning agents are put into use to sustain a clean and

healthy life. The hazards coming from these substances should definitely be known (Karapınar, 2015). To begin with clarifying the schema in individuals' mind in relation to cleaning agents would be a wise step to take. Upon the results coming from this step misunderstandings can be resolved or more emphasis can be put on the issue.

While identifying a cognitive structure, two concepts are of use: structure of knowledge and structural knowledge. Structural knowledge requires presenting the relationship between the concepts in the field in question while cognitive structure entails to focus on individuals' basic factors of conceptual understandings (Liu & Ebenezer, 2002). Individual come across many different concepts during their life time and absorb them through cognitive processes. The structure made upon these concepts in the brains of individuals can be revealed with the help of key concepts (Gilbert, et al., 1998). Educators have the deepest interest in the correct understanding and interpretation of any notion. In order for a notion to be understood correctly and made consistent in the mind it should be associated with the other notions in the brain (Bahar et al., 2006). The more notions to be associated, the easier it becomes to understand the new ones (Kaya & Taşdere, 2016).

Cognitive structure is a structure that reveals relationships between concepts in the long-term memory of individuals (Shavelson, 1974). Knowing the cognitive structure of the individual shows students how they structure their knowledge and how they relate the new knowledge to the old knowledge, while it gives teachers and researchers information about the student's learning (Tsai & Huang, 2002). Examining the relationship between concepts is quite significant for learners in that it shapes their learning processes.

In determining the preliminary information and cognitive structure that students have, prediction-observation-explain, discussion of concepts, drawings and word association methods are used. Word association is about how individuals understand concept groups. It is used not only to reveal whether concepts are understood but also to understand sciences and situations. Literature suggests that there are study areas or topics within the field of chemistry where cognitive structure are determined; including the concept of dissolution (Derman & Eilks, 2016), general chemistry concepts (Cardellini & Bahar, 2000), basic chemistry concepts (Yiğit, 2016), physical and chemical change concepts high school level (Nakiboğlu, 2016) and primary education level (Yildirir & Demirkol,

2018). Upon reviewing the literature, no studies with regards to the damages of chemicals on human health and nature and conducted with high school students has been found. Conducting research studies among youngsters bears utmost importance in raising environmental awareness. Therefore, the purpose of this research is to determine the cognitive structures of high school students on "cleaning agent" and identify alternative concepts by using independent word association test and drawing-writing technique.

METHOD

In the study, phenomenology method, which is one of the qualitative research methods, was used. Phenomenology explains the phenomenon in question of which the researcher is well aware but not have a detailed understanding. Phenomenology method is used to investigate cases which has a meaning we cannot fully grasp (Yıldırım & Şimşek, 2006). In this kind of studies how participants make sense of, describe and experience a phenomenon like a notion, an idea or an emotion is examined exclusively (Creswell, 2020). Henceforth, the actual phenomenon here is the meaning, the structure and the essence of the experiences of an individual or the individuals in a group (Patton, 2018). In this study, the cognitive structures of high school students about cleaning agent were examined with word association test.

Participants

The sample of this study consists of 160 high school students who continue their secondary education in Turkey. These students attend the 9th grade in an Anatolian High School in Turkey. The study group was determined by purposeful sampling method. This group was chosen as the sample because there is a subject of cleaning agents in the 9th grade curriculum of high school in Turkey. Students were informed about the purpose of the study and the data tools in advance. Consent form was obtained for voluntary participation. The cognitive structures of the high school students who participated in the study in relation to the cleaning agent were examined by means of the independent word association test.

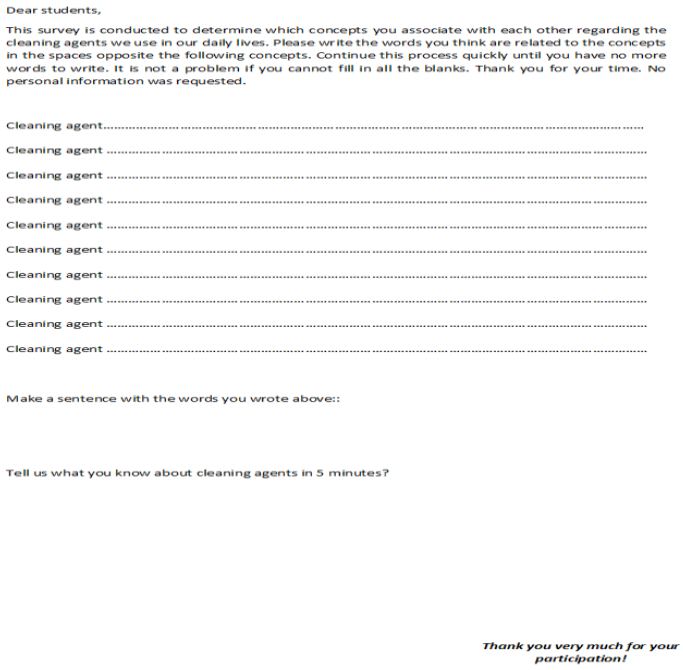
Word Association Test

In the present study, a word association test was used as a data collection tool. The test consists of three sections. In the first section, any word associated with the key concept is written down. In the second section, which is called the writing section, sentences are formed for each word written above. In the third section, which is called the drawing section, a drawing is made based on the phenomenon associated with the key

concept. While applying the word association test, care was taken to provide sufficient time and to explain the points that were difficult to understand. The word association test prepared for the current study was applied to 160 high school students. Since 3 high school students did not fill out the form completely, they were not included in the evaluation. Thus, a total of 157 high school students were include in the data analysis part. In the process of analyzing the obtained data, the method of categorizing and counting the concepts that come to mind about the concept of "cleaning agent" was used. The word association test applied in the research is shown in Figure 1.

Data Analysis

For the analysis of the gathered from the word association test, content analysis was run. The aim of content analysis is to reach the concepts that will explain the data and to reveal the relationships between these concepts (Yıldırım & Şimşek, 2006). The categories that come out of the data are combined, and categories are created (Creswell, 2018). The point to be considered while doing this process is to create and interpret data that is close to each other, namely the codes under a certain concept or category (Yıldırım & Şimşek, 2006). In the analysis of the data obtained from the word association test, the semantic relationship technique was used to reveal the number of words and the connection between these words (Atasoy, 2004). In the word association test, the connection between the words written about the cleaning substance, which is the key concept, was made by creating categories. These words and categories are shown in Table 1. Words that are appeared once and are not related to other words have not been evaluated. The concepts obtained were evaluated by the researchers in terms of relevance, and the answers determined to be valid were reflected in the results. The frequencies of the words in the created categories are given. For the analysis of data, the sentences gathered from the writing section and drawings gathered from the drawing section were also evaluated separately. Codes were created for the writings and extracts from students were also presented. Likewise, for the drawings another group of codes were created. In the word association test, word, sentence writing and drawing data and students' views on the key concept were discussed in more detail (Rennie & Jarvis, 1995). The results were analyzed taking the categories created according to the key concept into account.



Dear students,

This survey is conducted to determine which concepts you associate with each other regarding the cleaning agents we use in our daily lives. Please write the words you think are related to the concepts in the spaces opposite the following concepts. Continue this process quickly until you have no more words to write. It is not a problem if you cannot fill in all the blanks. Thank you for your time. No personal information was requested.

Cleaning agent.....

Cleaning agent .....

Cleaning agent .....

Cleaning agent .....

Cleaning agent .....

Cleaning agent .....

Cleaning agent .....

Cleaning agent .....

Cleaning agent .....

Cleaning agent .....

Make a sentence with the words you wrote above::

Tell us what you know about cleaning agents in 5 minutes?

Thank you very much for your participation!

Figure 1. Word association test for cleaning agent keyword

RESULTS AND DISCUSSION

Results from the Word Association Test

As a result of the analysis of the data obtained by using the word association test of the cognitive structures of the high school students regarding the cleaning agent concept, 3 main categories were created. According to the word association test, a total of 1400 answer words were collected from 157 students. 120 words (8.57%) were excluded from the evaluation due to reasons such as being unrelated to the subject or other words and being appeared once (Kostova & Radoynovska, 2010; Kurt 2013). 1280 words were obtained from the word association test and these were divided into 3 main categories as a total of 35 words, which can be seen in the Table 1.

When the Table 1 is analyzed, it can be seen that the answers given by high school students regarding the concept of cleaning agent are collected in 3 main categories as natural cleaning agent, chemical cleaning agent and cleaning equipment. While the main category of chemical cleaning agent consists of 2 sub-categories, namely personal cleaning agents and general cleaning agents, the main category of cleaning equipment consists of sub-categories of electronic equipment and non-electronic equipment.

The first main category is the "Natural cleaning agent" category. In this category, there are 6 words in total, namely White soap, Water, Arabic soap, Vinegar, Washing Soda, Carbonate, and the total frequency is 232. In the main

category of natural cleaning agents, students focused on white soap (132), water (51), Arab soap (31), vinegar (8), laundry soda (6), and carbonate (4). The second main category is the "Chemical cleaning agent" category. The frequency of this main category, consisting of 2 subcategories, is 792. While the frequency of the personal cleaning agents subcategory is 391, the frequency of the general cleaning agents subcategory is 501. Sub-category of personal cleaning agents shampoo (110), toothpaste (52), skin care product (38), shower gel (28), gas fragrances (deodorant) (28), conditioner (13), liquid fragrances (perfume) (13), acetone (9), expressed in words. General cleaning agents subcategory detergent (112), bleach-ozone water (130), cif (54), dish detergent (46), salt spirit (28), glass cleaner (26), descaler-solvent (25). It consists of the words: Softener (20), degreaser-remover (18), liquid soap (18), surface cleaner (13), and drain opener (11). The third main category is the "Cleaning equipment" category. The frequency of this main category, which has 2 subcategories, is 256. The frequency of the electronic equipment category is 46, and the frequency of the non-electronic equipment category is 210. The electronic equipment category consists of the words washing machine (17), vacuum cleaner (16), and dishwasher (13). Non-electronic equipment category consists of the words cloth (57), towel (35), wet wipe (33), toothbrush (33), vehicle-vileda (29), and sponge (23).

Some words are not included in these categories because the students use once or are not related to the subject; garbage truck, aspirin, eraser, nail clipper, antibacterial gel, raki, hand cream, hand water, comb, hair dye, bath, body water, gloves, cotton, garbage bag, fragrance, spring, flower, disinfect, make-up material, shaving razor, conditioner, ear cleaning stick, clay, my mom, insecticide, ear cleaning stick, brush, liquid, air cleaner, fountain, petrol, pouch, basin, festive cleaning, mother, dental floss, ablution.

Results from the Writing Sections

Students were asked to set up a sentence for the concept of cleaning agent in writing section. These sentences written by students were also analyzed. According to the analysis, frequency distributions of the sentences written by the students were made based on the determined categories. In Table 2, the frequencies of the sentences that students wrote about the concept of cleaning agent are given.

When the Table 2 is examined, it is seen that the highest frequency value is in the category of "Chemical Cleaning Agent" (f: 46). Examples of sentences in

this category are given below. In addition to the sentence examples, the numbers represent the codes given to the students.
S23: Bleach damages the skin during cleaning.
S33: We clean and smell good using shampoo and shower gel.

The second high frequency value is in the category of "Natural cleaning agent" (f: 23). Examples of sentences related to this category are as follows.
S13: We should wash our hands with soap every day.
S25: Water is the most important cleaning agent.
S110: Lemon-carbonate is a natural cleaning agent.

The findings as reflected in Table 2, suggest that the lowest frequency value is in the category of "Cleaning equipment" (f: 11). Examples of sentences describing this category are below.
S15: Cleans the dirt with cloth and water.
S48: Dishes are cleaner in the dishwasher.

Results Gathered from Drawing Section

Drawings made by the students in the third section of the word association test as for the phenomenon associated with the key concept are analyzed. The findings for the analysis of these drawings made by 135 students are summarized in Table 3.

Findings related to student drawings in Table 3, suggest that the highest frequency value is in the natural cleaning agent (f:55), second in the chemical cleaning agent (f:53) and cleaning equipment (f:27) categories.

Results of Cognitive Structure Related to Cleaning Agent

Upon analysis of the data gathered from word association test, a model for the cognitive structures of high school students in relation to cleaning agent was devised (Figure 2).

According to Figure 2, the cognitive structures of high school students regarding the concept of cleaning agent are grouped under three categories.

This research study was conducted to determine the cognitive structures of high school students related to the concept of "cleaning agent". For this, independent word association test was used. When the words obtained from the word association test were examined, it was noticed that the students had quite a variety of concepts (f: 1280). Moreover, it was found out that the concepts related to the cleaning agent were clustered around 3 main categories: Chemical cleaning agent, Natural cleaning agent and Cleaning equipment. "Chemical cleaning agent" is the main category having the highest frequency among all the categories (f: 792). In this category, personal cleaning agents (f: 291) are

represented by 8 words and general cleaning agents (f: 501) by 12 words. The main category of cleaning equipment is represented by 9 words (f: 56). In the independent word association test, students were asked to form sentences related to the words they wrote. When the sentences are examined, it is noteworthy that the highest frequency value is in the category of chemical cleaning agent (f: 46).

The students emphasized in their sentences that the chemical cleaning agent harms human health and that chemicals should not be used in large amounts while cleaning. When the sentences are examined, the category of natural cleaning agent is represented by 23 sentences. Students expressed the importance of the natural cleaning agent by referring to soap, vinegar, lemon-carbonate and water. The category represented by least among the sentences is the category of cleaning tools (f: 11). In the sentences, the students emphasize the necessity of cleaning tools. In the last stage of the word association test, students were asked to explain their knowledge of the key concept by drawing. When the drawings were examined, 135 of them were taken into consideration. It was discovered that the natural cleaning agent category had the highest frequency (f: 55), the chemical cleaning agent category was in the second place (f: 53); and the cleaning equipment category had the lowest frequency (f: 27).

Many of the events we experience or realize in our daily life are related to chemistry (Coştu et al., 2007). When the studies in chemistry teaching are examined, students perceive chemistry as a means of understanding facts (Derman, 2014), perceive it as a whole that includes interrelated subjects (Anılan, 2017), find it complex because it is related to formula and numerical values (Dönmez Usta & Ültay, 2015), nature, life, water, etc. it is understood to be detailed and inclusive (Özkurt-Sivrikaya, 2019). Cognitive tests based on applications are very useful and educational in terms of ease of preparation and application (Taufik et al., 2021). Critical thinking skills can be developed with classroom practices related to substances such as acids and bases that we use in our daily lives (Azzahra & Simatupang, 2021). However, cleaning agent breaks the leg by being so related to everyday life (Elmas, 2012). In order for students to understand the working mechanism of cleaning agents and to learn which factors affect the cleaning process, it is necessary to reconcile the content of chemistry with daily life (Giammatteo & Valdivia, 2021). Chemistry knowledge is very important for understanding natural events, protecting nature and minimizing

Table 1. Distribution of the Cognitive Structure Obtained by the Independent Word Association Test Related to the Concept of "Cleaning Agent" by Category

Categories	Concepts and Frequencies		Total Frequencies
Natural Cleaning Agent	White soap (132) Water (51) Arabian soap (31) Vinegar (8) Washing soda (6) Baking Soda (4)		232
Chemical Cleaning Agent	Personal cleaning agents	Shampoo (110) Toothpaste (52) Skin care product (38) Gas fragrances (28) Shower Gel (28) Conditioner (13) Liquid fragrances (13) Acetone (9)	291
	General cleaning agents	Bleach-ozone water (130) Detergent (112) Cream cleanser (54) Dishwashing liquid (46) Salt Spirit (28) Glass cleaner (26) Descaler-remover (25) Softener (20) Degreaser-remover (18) Liquid soap (18) Surface cleaner (13) Drain opener (11)	501
Cleaning Equipment	Electronic equipment	Washing machine (17) Broom (16) Dishwasher (13)	46
	Non-electronic equipment	Cloth (57) Towel (35) Wet Wipes (33) Toothbrush (33) Vehicle-vileda (29) Sponge (23)	210
Total		35 words	1280

Table 2. Distribution of Sentences Related to the Concept of Cleaning Agent by Categories and Frequencies

Main Categories	Frequencies
Natural Cleaning Agent	23
Chemical Cleaning Agent	46
Cleaning Equipment	27
Total	11

Table 3. Distribution of the Results Obtained by the Drawing Technique on the Concept of Cleaning Agent by Categories and Frequencies

Main Categories	Drawing (f)
Natural cleaning agent	55
Chemical cleaning agent	53
Cleaning equipment	27

Figure 2. Cognitive Structure for the Concept of Cleaning Agent

the damage done by human beings to the nature. Teachers have a big duty here. Combining daily life with chemistry allows students to increase their achievements, and at the same time, enables us to realize the chemical properties of the substances we use in daily life. When students are noticed that knowledge of chemistry is not only about theoretical knowledge, but is related to daily life as well, the interest in chemistry will increase and learning will become more meaningful (Ayas et al., 1997). During the early childhood phase, to become environmentally aware stage should be completed by protecting the environment or knowing what damages the environment (Sterling, 2009). Students can be taught about the effects of chemicals on human health and on the nature by making use of chemistry's relation with everyday life.

CONCLUSION

According to the results of this research study, it is remarkable that high school students separate the cleaning materials as natural and chemical. Besides, they create sentences about the damages done by chemical cleaning agents on human beings and nature, which is a sign of their awareness on this issue. Henceforth, cleaning agents can be taught within the scope of high school chemistry curriculum in accordance with the following suggestions.

In Turkey, the curriculum for 9th grade covers the subject matter "The Effects of Chemicals on Human Health and Environment" in the unit "The Science of Chemistry". In this part, damages coming from the wrong use of cleaning agents on human heath like respiratory and skin disorders should also be mentioned.

In the "Environmental Chemistry" section of the 9th grade "Nature and Chemistry" unit, the effects of chemicals on the environment are emphasized. While teaching this subject, it should be given with the information that detergents can cause harm to human health, respiratory and skin disorders.

In the 10th grade curriculum, items used in daily life for cleaning purposes are to be included in the "Acids, Bases and Salts" unit with an emphasis on their harms on human health and nature.

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