



## INVESTIGATION OF STUDENTS' COGNITIVE STRUCTURES AND CHANGES IN UNDERSTANDING ON THE TOPIC OF “INVENTIONS” USING WORD ASSOCIATION TESTS<sup>i</sup>

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### **Abstract:**

Word association tests, first used in the field of psychology to understand people's subconscious thoughts, began to be used in the field of education over time to determine the kind of connections students make between concepts, reveal misconceptions, and assess whether these connections are sufficient. In this study, word association tests were used as a pre-test and post-test to reveal students' misconceptions, the kinds of connections they made between concepts, and to see whether these connections were sufficient or not. The study sample comprised 32 3rd grade students. A word association test prepared by the researcher was used as the data collection tool in the study. The word association test consisted of the words “invent,” “inventor,” “technology,” “need,” and “innovation.” The cut-off point technique was used to analyze the data of the word association test. The pre-test indicated that the students frequently talked about key concepts from daily life. It was observed that the students had some misconceptions. The post-test revealed that the involvement of students' responses to key concepts with the subject increased, and misconceptions were largely eliminated.

**Keywords:** word association test, constructivist education approach, evaluation processes

### **Özet:**

İlk olarak psikoloji alanında, insanların bilinçaltındaki düşüncelerini ortaya çıkarma amacıyla kullanılan kelime ilişkilendirme testleri zaman içinde eğitim alanında öğrencilerin kavramlar arasında kurdukları bağlantıları, bu bağlantıların yeterliliğini ve kavram yanılgılarını belirlemek amacıyla kullanılmıştır. Bu çalışmada da kelime

<sup>i</sup>KELİME İLİŞKİLENDİRME TESTİ İLE “İCATLAR” KONUSUNA İLİŞKİN ÖĞRENCİLERİN BİLİŞSEL YAPILARININ VE KAVRAMSAL DEĞİŞİMLERİNİN İNCELENMESİ

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ilişkilendirme testleri ile ön test ve son test olarak öğrencilerin kavramlar arasında kurdukları bağlantıların, bu bağlantıların yeterliliğinin ve kavram yanılgılarının ortaya çıkarılması amaçlanmıştır. Çalışmanın örneklemini otuz iki 3. sınıf öğrencisi oluşturmaktadır. Çalışmada veri toplama aracı olarak araştırmacı tarafından hazırlanan kelime ilişkilendirme testi kullanılmıştır. Kelime ilişkilendirme testi "icat, mucit, teknoloji, ihtiyaç, yenilik" kelimelerinden oluşmaktadır. Kelime ilişkilendirme testinin verilerini analiz etmek için kesme noktası tekniği kullanılmıştır. Yapılan ön test sonucunda öğrencilerin anahtar kavramlara yönelik olarak sıklıkla günlük yaşamdan yanıtlar verdikleri belirlenmiştir. Ayrıca ön test sonucunda öğrencilerin birtakım kavram yanılgılarına sahip oldukları ortaya çıkmıştır. Son test sonucunda ise öğrencilerin anahtar kavramlara verdikleri yanıtların konu ile ilişkisinin arttığı, kavram yanılgılarının büyük oranda ortadan kalktığı gözlenmiştir.

**Anahtar sözcükler:** kelime ilişkilendirme testi, yapılandırmacı yaklaşım, değerlendirme süreci.

## 1. Introduction

With the increase in the effectiveness of the constructivist approach in primary education programs, there have been differences in the assessment and evaluation processes and tools used in the evaluation of educational activities. According to the constructivist education approach, students take new information in a social context, make sense of it subjectively, and interpret and build on their previous learning by associating new information with their previous learning (Brooks & Brooks, 1999). In the constructivist approach, the prior knowledge of the student, how he/she interprets and structures the information in the process, and how he/she relates old and new information is important. For this reason, in the constructivist approach, besides the techniques evaluating the product emerging in the learning process, the techniques used to measure and evaluate the readiness and learning process of students before learning takes place are included. Therefore, it can be said that alternative assessment and evaluation techniques are based on the constructivist approach (Anderson, 1998; Mintah, 2003). Alternative assessment and evaluation techniques focus on the pre-learning and learning processes that emerge, as well as the product itself and consider assessment as a part of the learning process. One of the main purposes is to determine where the student is in the learning process (Gelbel & Kellecioğlu, 2007). In traditional assessment and evaluation methods, measurement evaluations are made to evaluate the product obtained at the end of the process rather than assessment before and during the teaching-learning process (Anderson, 1998; Acar & Anıl, 2009). Traditional assessment techniques consist of multiple-choice, true-false, matching, short-answer, and long answer exam questions, and students are asked in a way that helps them remember the information that they have memorized before. In traditional assessment and evaluation techniques, students are expected to answer the questions within a certain time period (Duban &

Küçükylmaz, 2008; Gao & Grisham-Brown, 2011). Alternative assessment techniques include performance tasks, student portfolios, projects, rubrics scales, attitude scales, student assessments (e.g., self-evaluation and peer evaluation), diaries, observation forms, interviews, posters, presentations concept maps, concept networks, word association tests, structured grid, and diagnostic branched tree technique (Krulick, Rudnick & Milou, 2003). The purpose of such measurement tools is to reveal the higher-level thinking skills and creativity of students. It is an evaluation based on a process-oriented assessment and evaluation based on considering the strengths and weaknesses of the students during the learning and teaching process through cognitive, affective, or psychomotor activities and correcting or improving them where students also participate in the process (Özdemir, 2010).

This study aimed to reveal the cognitive structures of students through word association tests, an alternative measurement and evaluation technique, to observe the change in their cognitive structures after the teaching process. Word association tests can be used to determine how responders make connections between concepts in any topic, as well as their readiness and misconceptions about the topic.

### **1.1 Word Association Test**

Word association tests are among the primary measurement tools used to establish cognitive connections (e.g., ideas and concepts) and to reveal them. The purpose of word association tests is that individuals can improvise words for a specific subject, concept, or idea within a limited time (Bahar, Johnstone & Sutcliffe, 1999; Stacy, Ames & Grenard, 2006; Strauss, Sherman & Spreen, 2006). Word association tests were first used by the psychoanalyst Galton (1879) in the field of psychology to reveal various aspects of people's subconscious. This method was widely used after Kent and Rosanoff's work (1910). They used the word association tests in a way close to their current usage for the first time. After Kent & Rosanoff (1910) prepared an extensive list of words, they asked participants to list the words they associated with key concepts and the associations that the key concept created in their minds. It was found that participants made similar connections between the same words (Ross, 2003; Kostavo & Radoynovska, 2008; İstifçi, 2010; Enguix, Rapp & Zock, 2014; Ustaoglu & Aytac, 2014)

Word association tests can be applied as "free word association tests" and "controlled word association tests." In free word association tests, participants are given one or more keywords and asked to rank the words associated with these words. There are no limitations on the participants in terms of association. In controlled word association tests, keywords and concepts thought to be related to keywords are given. Participants are asked to rank concepts from what they think is most relevant to the keyword to what they think is least relevant (Tsai & Huang, 2002; Ross, 2003; Stacy, Ames & Grenard, 2006). Sentence completion activities can also be done to check whether the answers given in word association tests are meaningful.

Word association tests are evaluated in two ways. In the correlation coefficient method, the words having a stronger relationship are determined with this method. First,

a frequency table is created indicating the number of words produced for each key concept. By having the keyword at the top of the frequency table, a ranking toward the least repetitive response is established and graded from top to bottom. Afterwards, all the data obtained are analyzed, and the average correlation coefficient is calculated for each keyword pair. Another type of evaluation is the cut-off technique. In this technique, a frequency table is created from repeated responses for key concepts. The frequency table obtained is transformed into a concept network and used to reveal the kind of connections the respondents make between concepts. Concept networks are created according to the cut-off method, in which starting from the highest frequency point, it is pulled down until a certain frequency point is reached and cutting is applied at the specified point. The pull-down and cutting process is repeated until the concepts at the lowest point of the frequency are reached. All concepts are included in the concept network at the last breakpoint (Bahar, Johnstone & Sutcliffe, 1999; Tsai & Huang, 2002; Güneş & Gözüm, 2003; Nakiboğlu, 2008; Ustaoglu & Aytac, 2014). Creating a concept network with word association tests provides systematization and organization of not only learned concepts but also newly learned concepts. Concept networks and new knowledge and experiences are being used effectively together (Bahar & Özatlı, 2003; Kostavı & Radoynovska, 2008).

Word association tests are frequently used as an assessment and evaluation tool in the field of education because they reveal the cognitive structure of individuals, the relationships they establish among concepts in their long-term memory, and whether these relationships are sufficient and meaningful. If students can associate their old knowledge with new ones and organize them properly, meaningful and permanent learning takes place. In other words, one of the requirements for learning to be meaningful and permanent is that individuals associate their new lives with their past experiences. Various measurement tools are needed to determine whether this association process has been structured correctly. Word association tests are one of the measurement tools that reveal the relationships between old knowledge and new information and concepts.

Word association tests are used frequently to reveal the kind of relationships students establish between concepts and whether these relationships are meaningful and sufficient (Bahar, Johnstone & Sutcliffe, 1999). Word association tests are used not only to reveal the relationships among concepts in students' minds but also to reveal students' readiness and misconceptions.

In this study, the word association test was used as a pre-test and a post-test to determine the cognitive levels of students in the subject of "inventions" in a social studies course and how they establish relationships among concepts. The pre-test through a word association test for the "inventions" unit of a social studies lesson was used to reveal the concepts students associate with key concepts and their misconceptions. For this purpose, answers to the following questions were sought:

- 1) What kind of connections did students make between concepts in the pre-test word association test for the subject "inventions" in the social studies lesson?

- 2) What kind of connections did students make between concepts in the post-test word association test on the subject "inventions" in the social studies lesson?
- 3) When the pre-test and post-test results of a word association test applied to the subject "inventions" in the social studies lesson were compared, were there any differences in the relationships students establish between concepts?

## **2. Method**

In word association tests, a word list is created depending on a rule or category in a limited time period (Ross, 2003). Word association tests consist of two tables. In the first table, the word to be associated is written over and over again. In the adjacent blanks, there are spaces that the responder needs to fill according to the word in question (Dollinger, Levin & Robinson, 1991). Respondents write the words they see as related to the key concept in the given time (mostly 30 seconds). Bahar & Özatlı (2003) state that the key concept was written over and over again to eliminate the risk of chain responses. Accordingly, the responder returns to the key concept before creating each new answer and responds by associating it with the key concept. In word association tests, students answer the questions that are evoked by the key concept given on the subject within the given time. It is thought that the answer given by the student reveals the relationships and semantic closeness between the concepts in long-term memory. In semantic memory, the closer the two concepts are to each other in terms of distance, the faster the response to the concepts during recall (Bahar & Özatlı, 2003).

### **2.1 Study Group**

The study group comprised 32 students in 3rd grade who were attending social studies classes. The study sample was determined through simple random sampling method. In this method, every individual in the universe has an equal chance of being selected for the sample. For each possible sample of a certain size, each sample drawn from the universe with equal probability is called simple random sampling (Johnson & Christen, 2014).

### **2.2 Data Collection Tool**

Word association test was used in pre-test and post-test as a data collection tool. The word association test was prepared by determining five key concepts associated with the subject. While determining the key concepts, the third grade social studies program and textbooks affiliated to the Ministry of National Education were examined. After the word association test was prepared, the opinions of an academician in the elementary school teaching program and two classroom teachers were taken. As a result, the concepts "innovation," "need," "invention," "technology," and "inventor" were determined as key words. In the word association test application paper, it was first explained how the word association test would be applied. In addition, the application process of the word association test was explained to the students verbally before the application.

Afterwards, each keyword was written five times one under the other, and spaces were left in front of them for students to write their answers. Students were given 1 minute for each keyword. In previous studies, the study group was generally given 30 seconds for each keyword. However, because the age level of the study group was low, it was thought that it would be appropriate to give the participants more time.

### 2.3 Data Analysis

The cut-off technique (Bahar, Johnstone & Sutcliffe, 1999) was used, in which a frequency table is created from the answers of each student given for each keyword. Three to five numbers below the most common number of responses to keywords is used as a cut-off point. The upper part of the cut-off point forms the first part of the concept network. The cut-off process continues at the same intervals until all responses to the keywords are included in the concept map.

Word association tests were used as pre- and post-tests in the study. While analyzing the data obtained from the word association test, their answers in the pre- and post-tests were examined one by one. In this study, the responses given by the students were examined one by one, and a frequency table was created. In the next stage, breakpoints were defined by reducing the number of words 10 by 10, and the cut-off was continued to be created in each response area on the concept map.

### 3. Results

First, a frequency table was created from the answers given in the pre-test and post-test in the word association test. After creating the frequency table, a concept map was created using the cut-off point technique, and the associations that students created between concepts were determined. In the analysis of data in pre-test, it was 20 and above (Table 2), 19-10 (Table 3), and 9-1 (Table 4). It was 20 and above (Table 5), 19-10 (Table 6), and 9-1 (Table 7) in the post-test. When the prepared concept maps are examined, it is observed that the number of concepts and the relationships among them increase as the cut-off point goes down in the pre-test and post-test.

It is thought that the greater the number of words produced about a concept, the more successful the student is in understanding that concept.

**Table 1:** Number of responses to key concepts

Key concepts	Pre-test word numbers	Post-test word numbers
Invention	102	158
Technology	99	160
Inventor	98	121
Need	101	143
Innovation	137	141

**Table 2:** Pre-test frequency table – Frequency point 20 and above

Edison	INVENTOR	INVENTION	Computer
Money	NEED	TECHNOLOGY	Computer
Home		INNOVATION	
Clothes			

**Table 3:** Pre-test frequency table – Frequency point between 19 and 10

Edison	INVENTOR	Graham Bell
Galileo		
Computer	INVENTION	Phone
Telescope		Television
Computer	TECHNOLOGY	Television
Phone		Tablet
Home	INNOVATION	Clothes
Goods		Car
Bike		
Home	NEED	Doctor
Food		Money
Education		Car
Tablet		Clothes
Goods		

**Table 4:** Pre-test frequency table – Frequency point between 9 and 1

Graham Bell	INVENTOR	Ibn Sina
Pastör		Mehmet Akif Ersoy
Aziz Sançar		Piri Reis
Archimedes		Einstein
Galileo		Edison
Scientist		Pythagora
Telescope	INVENTION	Camera
Electricity		Photo
Radio		Submarine
Dish washer		Airplane
Goods		Computer
Robot		Telephone
Lamp		Television
Clothes	Owen	
Computer	TECHNOLOGY	Television
Phone		Tablet
Owen		Internet
Telephone		Speaker
Ease		Car
Stove		Development
Broom		Projection
Home		Clothes
Goods	INNOVATION	Car
Bike		Brother
Book		Toy

Pen	NEED	Neighborhood
Doctor		Happiness
Family		Projection
Oxygen		Home
Bike		Goods
Money		Friend
Tablet		Water
Serenity		

The results in Table 2, 3, 4 can be interpreted as follows:

According to the pre-test results, there are four responses with a cut-off point above 20. In the study, it is seen that it consists of the words "Edison," "home," "clothes," "money," and "computer." It is seen that the concept of "need" is associated with students' daily basic needs. It has been determined that the concepts of "invention" and "technology" are associated with computers that have become an important part of their daily lives. It is thought that the word "bicycle" given to the key concept of "innovation" is confused with the words "innovation" and "new."

When the answers with a cut-off point of 19-10 were examined, it was found that the variety of the answers given increases. It has been observed that the key concepts were associated with objects they frequently encounter in their daily lives. In addition, based on the answers given by a group of students, there is confusion between the words "explorer" and "inventor." In addition, it is seen more clearly at this point that the words "innovation" and "new" are confused by the students.

When the answers with a cut-off point of 9-1 were examined, it was found that misconceptions increase while the answers given continue to enrich. Responses to the concepts of innovation and need are more common in response to words related to their daily lives.

**Table 5:** Post-test frequency table - Frequency point 20 above

Edison	INVENTOR	TECHNOLOGY	Science
Tesla		NEED	Money
Scientist			Home
Scientist	INVENTION		Clothes
		INNOVATION	Change

**Table 6:** Post-test frequency table - Frequency point between 19-10

Tesla	INVENTOR	Aziz Sancar
Edison		Edison
Ibn Sina		Inventor
Patience	INVENTION	Scientist
Research		Computer
Inventor		Innovation
Innovation	TECHNOLOGY	Science
Computer		Development
Need		

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Change	INNOVATION	Invention
Technology		
Education	NEED	Clothes
Home		Money
Technology		

**Table 7:** Post-test frequency table - Frequency point between 9-1

Tesla	INVENTOR	Aziz Sancar
Edison		Edison
Ibn Sina		Inventor
Madame Curçe		Galileo
Hezarfan Ahmet Çelebi		Diligence
Patience		Invention
Education		
Patience	INVENTION	Scientist
Research		Computer
Inventor		Innovation
Goods		Telescope
Lamp		Telephone
Innovation	TECHNOLOGY	Science
Computer		Development
Need		Telephone
Progress		Goods
Change	INNOVATION	Invention
Technology		Need
Education	NEED	Clothes
Home		Money
Technology		Car
Dining		Goods
Telephone		Innovation

The results in Table 5, 6, 7 can be interpreted as follows:

According to the post-test results, an increase was observed in responses with a cut-off point of 20 and above. While four responses were above 20 in the pre-test, there were eight answers over 20 in the post-test. When the responses for "inventor, innovation, invention, technology" are examined, it is seen that the answers are more related to the subject of "inventions." It is observed that there is no more confusion regarding the concept "innovation" with the concept "new." When the responses to the key concept "need" are analyzed, it is seen that students respond with words that they frequently encounter in their daily lives, as in the pre-test.

Answers with a cut-off point of 19-10 also increased, while it was observed that students gave similar answers more frequently. In addition, it is seen that key concepts are associated with each other at this stage. In the post-test, an increase was observed in the more relevant and qualified responses of the students. Especially for the key concepts "inventor, innovation, invention, technology," the variety of concepts related to the

subject has increased. It is seen that the answers that were not given before started to be given.

When the answers with a cut-off point of 9-1 were examined, it was found that the concepts related to the key words have emerged to a large extent, and misconceptions have decreased significantly. The answers given for key concepts are more associated with each other.

#### **4. Discussion and Conclusion**

For the learning process to be successful, the teaching–learning process must be in accordance with the level of the student. Alternative approaches began to be preferred with the introduction of the constructivist approach in learning environments to determine students' preparedness levels. Because of alternative approaches, misconceptions can be determined to a large extent if the student has readiness levels related to the subject to be learned.

In this study, word association tests were used; these tests are an alternative assessment and evaluation approach. It was found that word association tests are an extremely effective tool for monitoring students' readiness levels, their misconceptions, and the changes in their understanding of concepts after the learning–teaching process. The findings of this study overlap with the findings of studies conducted in different fields using word association tests. Those studies have also determined that word association tests are effective in revealing the connections and misconceptions students have among concepts (Bahar, Johnstone & Sutcliffe, 1999; Tsai & Huang, 2002; Bahar & Öxatlı, 2003; Ercan, Taşdere & Ercan, 2010; Işıklı, Taşdere & Göz, 2011; Kaya & Akış, 2015).

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#### **Conflicts of Interest**

The author declare no conflicts of interest.

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