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The Effect of Using Word Cloud in Primary School Science Teaching on the Cognitive Structure of Students[1]

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Abstract

This study investigated the effects of creating word cloud activities on students' cognitive structures in a fourth-grade science course in primary school. The study was semi-experimental research, included 38 primary school students, and used the word association test for data collection. In data analysis, Mann Whitney-U Test and Wilcoxon Signed-Rank Test as the non-parametric tests, and their parametric equivalents were used together. Within the scope of the study, whereas the word cloud activity was performed in the experimental group, the teacher-centered teaching activity was conducted in the control group. The study's findings showed no difference between the groups in concept remembering but in meaningful propositions in favor of the experimental group.

INTRODUCTION

Technology innovation has affected many education areas and resulted in changes in curriculum, learning environment, learners' and teachers' roles, and teaching approaches (Alpar, Batdal & Avcı, 2007). Individuals who embrace change can develop into capable learners who can access information, acquire effective learning strategies, and apply their knowledge to real-world situations (Orkun & Bayırlı, 2019). Thus, learners must first be able to cope with technology. Therefore, students should also be provided with opportunities for active participation in the teaching process (Somuncuoğlu & Yıldırım, 1998). For teachers to meet these expectations, they must assign learning responsibilities to students and incorporate appropriate technologies into the instructional process while considering the technological advancements of the time (Gülcü, Aydın, Koçak & Solak, 2013). Technological developments have led to the occurrence of various Web 2.0 applications. O'Reilly (2005) reported that Web 2.0 encompasses all tools and activities that enable the creation of an interactive instructional environment. Horzum (2010) defines that Web 2.0 involves various devices and applications that allow people to experience multiple applications. By another definition, Alexander (2006) describes Web 2.0 as an interactive social software that lets users share ideas and participate in online activities. With today's technology, Web 2.0 offers conveniences and support for people of all ages, such as quick and easy access to data, interactive designs, sharing, and saving (Altun,

2008). Thus, beneficiaries can generate, edit, save, share, and evaluate products on the internet using Web 2.0 tools comfortably (Altıok, Yükseltürk & Üçgül, 2017; Elmas & Geban, 2015). Therefore, many passive users have become individuals who actively create, share, evaluate, interpret, and contribute to various types of content on the internet (Chen et al., 2012; Horzum, 2010).

The literature reported that the usage of Web 2.0 applications for teaching is increased, wide various new tools are being developed (Korkmaz et al., 2019; Özipek, 2019; Ramazanoğlu, 2019; Talang & Mahmoodi, 2013). Kahoot (Batıbay & Mete, 2019; Ramazanoğlu, 2019), Plickers (Akbaba, 2019; Akkaya, 2020; Korkmaz et al., 2019), Edmodo (Özkan, 2017), Padlet (Özipek, 2019), Storybird (Karadağ, 2018), Word Cloud (Afurobi et al., 2015; Dağ Gülcan, 2013; Le & Lauw, 2016; Viegas et al., 2009; Viegas & Wattenberg, 2008; Yıldız, 2015) are among the applications discussed in the literature. In these studies, variables such as attitude, motivation, and self-efficacy are noticed to be investigated, as well as variables such as educational benefit, integration into the learning environment, level of use, and academic success. These studies have indicated that Web 2.0 tools can positively affect affective areas such as attitude, motivation, and self-efficacy (Acar & Gülnar, 2018; Akbaba, 2019; Batıbay & Mete, 2019; Orhan & Men Durak, 2018). Additionally, conducted studies reported results on participants creating positive awareness about these tools and these applications using effectively by adopting these tools (Horzum, 2010; Ramazanoğlu, 2019). On the other hand, these applications have been expressed to possibly impact academic achievement (Akkaya, 2020; 2019; Korkmaz et al., 2019).

The word cloud is one of these WEB 2.0 activities. Word clouds are effective and practical tools to facilitate teaching (Perveen, 2021). According to McNaught & Lam (2010), word clouds are expressed as specific visualizations of textual information. Visualization of the text is based on the conversion of word frequencies into a visual representation. Hence, words frequently appearing in the word cloud are emphasized by being more prominent. Since word clouds have become increasingly popular, many different word cloud activities have emerged (Halvey & Keane, 2007). To visualize, users can either load a ready-made text or determine the words themselves through these activities. As Baralt et al. (2011) have mentioned, the activity offers the features of creating a word cloud according to the total word frequency by customizing the font, different themes, colors, and direction and excluding unwanted words.

According to Shavelson (1974), the cognitive structure reflects the concepts and the relationships of concepts in a student's long-term memory. The cognitive structure has also been mentioned to be important in facilitating our learning and retaining what we have learned. At this point, the changes in students' cognitive structure are stated to be necessary for learning (Kurt & Ekici, 2013). Very few studies have been determined to be carried out regarding science courses in the literature on Web 2.0. Moreover, these studies are noticed to be carried out only on science courses' various topics in middle school grades (Akbaba, 2019; Akkaya, 2020; Gürleroğlu, 2019). The word cloud is considered a popular technique for creating an aesthetic and expressive visual representation of textual expressions (Li, Dong & Yuan, 2018). Despite the emphasis placed on the positive potential of word clouds in education, there are only a limited number of studies investigating their impact on teaching when reviewing national and international research (Afurobi et al., 2015; Dağ Gülcan, 2013; DeNoyelles & Foster, 2015; Mansouri, 2015; Miley & Read, 2011; Perry, 2012; Perveen, 2021; Talang & Mahmoodi, 2013; Yıldız, 2015). The present study investigates the effects of word cloud activities on primary school students' cognitive structures in biology subjects in the science course. Through word cloud activities, students were tested on their ability to remember terms and concepts and their

ability to create meaningful propositions. Accordingly, the research problem of the study was as follows:

Does instructing the subject "Our Foods and Their Properties" in the science course using the word cloud reveal significant differences in students' cognitive structures?

Sub-problems related to the study were presented accordingly.

Problems of the Study

1. Is there any significant difference between the groups' pre-test scores?
2. Is there any significant difference between the groups' post-test scores?
3. Is there any significant difference between the pre- and post-test scores of the experimental group?
4. Is there any significant difference between the pre- and post-test scores of the control group?

METHOD

The study groups were determined randomly, but the participants in these groups could not be assigned randomly. Therefore, the study was realized with the pre-and post-test control group design, which was quasi-experimental.

Study Group

The study groups included students in a primary school's 4th class in the 2021-2022 year. Since some students only participated in part of the process, they were excluded from the data analysis. Totally 38 students were contained in the analysis. Table 1 presents the groups' gender frequencies. Accordingly, it is seen that the groups are similar regarding gender rates.

Table 1. The gender distribution of the study groups

Group	Gender	Frequency	Percentage (%)
Control	Female	10	52,63
	Male	9	47,37
	Total	19	100,00
Experiment	Female	9	47,37
	Male	10	52,63
	Total	19	100,00
Total	Female	19	50,00
	Male	19	50,00
	Total	38	100,00

This study's approval was primarily obtained from the Educational Sciences Human Research Ethics Committee at Erzincan Binali Yıldırım University. Additionally, permission to apply was obtained from the Provincial Directorate of National Education, where the study was conducted. The school administration and teachers were informed about the activity. The parents were informed about the participation of the students with the parent consent form, and their consent was obtained. Personal and institutional information was not collected and used in the study.

Development of WAT and Data Collection

In this study, the concept of "Food" was selected to create the Word Association Test. The concept was chosen because it provided a basic structure and general framework for the

subject. This key concept was written 24 times on a page with spaces to write the words the student thought relevant. Each of the four words was followed by a blank to be filled in with an association sentence. In the introduction part of the test, students were instructed on how to take it. A field expert and a classroom teacher analyzed the Word Association Test (WAT) in its present form, and their opinions were asked on suitability. In previous studies using the WAT, 30 seconds was regarded to be the most appropriate time (Bahar & Özatlı, 2003). Due to the study group being primary school fourth graders, the total duration of the study was determined to be ten minutes, including one minute for each section. For equal periods of time, the developed data collection tool was administered to both groups, without interruption, at the beginning and end of the activity.

The Study Process

Process of Preparation

From the "Living Beings and Life" subject area the "Our Food" unit was selected for the activity based on an analysis of the science curriculum and coursebook. In this unit, the subject of "Foods and Their Properties" was chosen, and the activities were planned on two acquisitions in this subject. An emphasis was placed on making the info text concise and simple and including the topic's main topics and key concepts. The info text was finalized by obtaining expert opinions regarding the necessary arrangements. The info text included 475 words. Students in both groups were given the same info-text.

Prior to the activity, "I am Learning with Word Cloud Task Cards" were developed for creating the word clouds in the experimental group. These cards included three questions for the experimental group students to answer using the information texts and coursebook. The researchers created these questions to include the essential concepts of the acquisition areas. In this context, "Basic Food Sources," "Benefits of Foods" and "Food Contents" were structured as different tasks.

Four instructions were given on each task card for creating a word cloud. These instructions included choosing words, writing them in the program, determining their frequency, and customizing the design. For one-course hour before data collection, the Word Association Test was introduced to control and experimental group students, and sample activities were conducted using a different topic's key concepts. The "WordArt" tool was introduced to the experimental group to create the word cloud. Moreover, the students had the opportunity to experiment with the interface related to entering words, the frequency, and customizing the design. Three-course hours were allocated for this process.

Activity Process

The study process was carried out by planning according to the pre-test and post-test control group design. Table 2 summarizes this study process.

The information texts were given to both groups to read as homework on the same day. Upon returning to school the next day, both groups performed the activities with their teachers in their classrooms for three-course hours. The control groups' students studied subjects and activities in the science coursebook with their classroom teachers. This teaching process was carried out as teacher-centered. Classroom teachers used the oral expression method, and open-ended questions from the coursebook related to the topic were included in the course. There were no experiments or technological activities performed aside from this. The teacher conducted a question-and-answer activity in the course's final part.

Table 2. Study process

Group	Pre-test	Activity	Post-test
Control	WAT	1. Giving the Info Text (Home Activity) 2. Teacher-Centered Instruction Appropriate to the Current Curriculum (In-class Activity) (3-Course Hours)	WAT
Experiment	WAT	1. Giving the Info Text (Home Activity) 2. Creating and presenting the word cloud (In-class Activity) (3-Course Hours)	WAT

There was no instruction provided to the experimental group by the teacher. This group's students were given task cards "I am Learning with Word Cloud" in the classroom and asked to complete the tasks using the information text and coursebook. Then, each student got a computer or mobile device and created a word cloud with the words they determined. Using WordArt, they wrote the words in word boxes, weighted the words according to their importance, and customized them (font, size, color, horizontal, vertical, or random customization of words). The prepared word clouds were presented to the class by the students. Creating the word clouds (WordArt activity) during the activity took longer than a one-course hour, whereas the other stages took less than a one-course hour.

Data analysis

Among the words written for the key concept in the WAT, the concepts and terms related to the key concept (protein, carbohydrate, vitamin, fat, water, mineral, plant food, etc.) were classified as conceptual knowledge (CK). The ones that had an indirect relationship with the key concept or sample food in terms of its content (fruit, milk, meat, olive oil, etc.) were classified as indirectly related knowledge (IRK). Likewise, the sentences related to the subject and informative were coded as meaningful propositions (MP) ("They are protein-making and regulatory foods," "Hazelnuts, walnuts are foods containing fat," etc.). On the other hand, the sentences that were independent of the subject and did not contain information ("I drank ice-cold water", "We ran out of butter in our house") were coded as unrelated propositions (UP). In the concepts written after this coding, the concepts coded as conceptual knowledge (CK) and indirectly related knowledge (IRK) were scored 1 point, and unrelated ones were scored 0 points. Similarly, Word Association Test proposition scores were obtained by scoring 1 point to the sentences coded as meaningful proposition (MP).

The distribution characteristics of the scores obtained from the tests were analyzed using descriptive statistics and the Shapiro-Wilk test before the statistical analysis was performed. Thus, it was discovered that the data set had no normal distribution. Non-parametric tests were performed since the data set did not meet the normality assumption. In this study, we utilized the Mann-Whitney U Test for independent groups' comparisons. Additionally, we used the Wilcoxon Signed Ranks test to compare two measurements obtained from the same data source. (Büyüköztürk, Çakmak, Akgün, Karadeniz & Demirel, 2017). Parametric equivalents of these tests were also used in the study. Since the results were similar, the average values were used to interpret the results.

Validity and Reliability

The Word Association Test prepared by a field expert and a classroom teacher was used in the study. The researcher used a predetermined rule to code the answers given in the concept and proposition analysis of the WAT. Since the coding was based on simple theoretical knowledge on the basis of words and propositions, the coding was shown to another field expert to take the opinion. The classroom teacher and field expert reached a consensus on this. The coding was rearranged and finalized based on the opinions. During the experimental process, identical conditions and materials were provided to both groups, except for the word cloud activity. Since the experimental and control group activities were carried out simultaneously, an interaction between the groups was not possible. The WAT was performed before the procedure to allow both groups to gain experience with the data collection tool.

FINDINGS

For Independent Groups Concept Analysis Results

The statistical results to analyze the difference between the groups regarding the pre-test and post-test scores were presented.

Table 3. Mann-Whitney and Independent Groups t-Test Results

Variable		Group	n	Mean	Std. Dev.	Mann-Whitney	p	t-test	df	p
CK	Pre-test	Control	19	1.36	1.60	193.00	0.70	0.00	36	1.00
		Experiment	19	1.36	2.03					
	Post-test	Control	19	2.15	2.69	141.50	0.25	-1.16	36	0.25
		Experiment	19	3.42	3.89					
IRK	Pre-test	Control	19	12.57	7.14	261.00	0.01	2.73	36	0.01
		Experiment	19	7.26	4.56					
	Post-test	Control	19	16.26	6.99	230.50	0.14	1.17	36	0.25
		Experiment	19	14.00	4.71					

*CK: Conceptual Knowledge IRK: Indirectly Related Knowledge

Table 3 shows that there was no statistically significant difference between groups regarding the pre-test conceptual knowledge ($t_{(36)}$=0.0; p>0.05). This result indicated that the two groups had similar conceptual characteristics at the beginning of the activity. In terms of indirectly related concepts, the difference in pre-test mean was found to be significant (X=12.57) in favor of the control group ($t_{(36)}$=2.73; p<0.05). In terms of the post-test findings, there was no difference between the groups in conceptual knowledge ($t_{(36)}$=1.16; p>0.05) and the indirectly related knowledge ($t_{(36)}$=1.17; p>0.05).

Concept Analysis Findings Related to Dependent Groups

The statistical findings for each group's initial and final results are presented in Table 4. As a result, the difference between the tests' means of the control group was not significant for the conceptual knowledge dimension ($t_{(18)}$=1.68; p>0.05), but significant for the indirectly related knowledge dimension ($t_{(18)}$=3.15; p<0.05). There was a statistical significant difference between the tests' mean of the experimental group in both conceptual knowledge and indirectly related knowledge dimensions ($t_{(18)}$=3.26, t(18)=4.14; p<0.05). Accordingly, it was noticed that whereas the pre-test conceptual knowledge mean was 1.36, it was 3.42 in the post-test. This indicated an increase in conceptual knowledge. It was also revealed that while the pre-test mean was 7.26 in terms of indirectly related knowledge, it was 14.00 in the post-test, and there was a rising end of the process.

Table 4. Wilcoxon and Paired Samples t-Test Results

Group	Variable	n	Mean	Std. Dev.	Wilcoxon	p	t-test	df	p
Control	Pre-test CK	19	1.36	1.60	19.00	0.12	-1.68	18	0.10
	Post-test CK	19	2.15	2.69					
	Pre-test IRK	19	12.57	7.14	17.50	0.01	-3.15	18	0.00
	Post-test IRK	19	16.26	6.99					
Experiment	Pre-test CK	19	1.36	2.03	9.00	0.00	-3.26	18	0.00
	Post-test CK	19	3.42	3.89					
	Pre-test IRK	19	7.26	4.56	14.50	0.00	-4.14	18	0 .00
	Post-test IRK	19	14.00	4.71					

*CK: Conceptual Knowledge IRK: Indirectly Related Knowledge

Propositional Analysis Findings Regarding the Independent Groups

The descriptive statistics and test results regarding the pre-test and post-test scores of the experimental and control groups in the dimension of creating propositions were presented in Table 5.

Table 5. Results for Mann-Whitney and Independent Groups t-Test

	Variable	Group	n	Mean	Std. Dev.	Mann-Whitney	p	t-test	df	p
Pretest	MP	Control	19	0.89	1.19	156.50	0.64	-0.87	35	0.38
		Experiment	18	1.33	1.81					
	UP	Control	19	4.78	1.96	225.50	0.09	1.67	35	0.10
		Experiment	18	3.61	2.30					
Posttest	MP	Control	19	1.36	1.70	23.00	0 .00	-7.44	35	0 .00
		Experiment	18	5.05	1.25					
	UP	Control	19	4.26	1.91	305.00	0 .00	5.80	35	0 .00
		Experiment	18	1.11	1.32					

*MP: Meaningful Proposition UP: Unrelated Proposition

When the table was analyzed, it was noticed that the difference between the pre-test scores of the groups was not statistically significant before the experimental activity (MP: $t_{(35)}$=0.87; UP: $t_{(35)}$=1.67; p>0.05). These findings indicated that the cognitive structures of the groups before the experimental activity were similar in terms of propositional, that is, conceptual relations. After comparing the post-test results of the groups, it was found that there was a statistically significant difference in favor of the experimental group in terms of meaningful propositions and in favor of the control group in terms of unrelated propositions (MP: $t_{(35)}$=7.44; UP: $t_{(35)}$=5.80; p>0.05). Considering that the increase in meaningful propositions and the decrease in unrelated propositions indicated an improvement in cognitive structure, the fact that the mean of unrelated propositions was statistically significantly lower in the experimental group than in the control group was a positive indication of improved cognitive structure. Therefore, at the end of the application, the number of unrelated propositions decreased, and the number of meaningful propositions increased in the experimental group compared to the control group. Accordingly, it was concluded that the experimental group was more successful at creating

meaningful relationships between concepts, and the number of unrelated propositions decreased as a result. Hence, word cloud activity performed in the experimental group was found to be associated with meaningful relationships in the cognitive structure of the participants.

Propositional Analysis Findings Regarding the Dependent Groups

Table 6 presents the statistical analysis results of paired t-test. Accordingly, the difference between the mean scores of MP and UP is not significant in the control group ($t_{(18)}$=1.34, t(18)=1.48; p>0.05). Contrarily, there was a significant difference between the experimental group's meaningful proposition ($t_{(18)}$=9.06; p<0.05) and unrelated proposition ($t_{(18)}$=4.12; p<0.05) pre-test and post-test scores.

Table 6. Wilcoxon and Paired Samples t-Test Results

Group	Variable	n	Mean	Std. Dev.	Wilcoxon	p	t-test	df	p
Control	Pretest MP	19	0.89	1.19	19.00	0.22	-1.34	18	0.19
	Posttest MP	19	1.36	1.70					
	Pretest UP	19	4.78	1.96	29.00	0.13	1.48	18	0.15
	Posttest UP	19	4.26	1.91					
Experiment	Pretest MP	18	1.33	1.81	0.00	0.00	-9.06	17	0.00
	Posttest MP	18	5.05	1.25					
	Pretest UP	17	3.82	2.18	125.50	0.00	4.12	16	0.00
	Posttest UP	18	1.11	1.32					

*MP: Meaningful Proposition UP: Unrelated Proposition

Whereas the pre-test meaningful proposition mean of the experimental group was 1.33, it increased to 5.05 in the post-test. The unrelated proposition, the mean was 3.82 in the pre-test, but it decreased to 1.11 in the post-test. This finding indicated that meaningful propositions increased and unrelated propositions in the cognitive structure of the experimental group decreased. In the control group, there was no significant difference in terms of establishing a relationship between the concepts during the activity.

CONCLUSION, DISCUSSION AND SUGGESTIONS

This study investigated the effect of word cloud activity in biology subjects on the cognitive structure of primary school fourth-grade students at conceptual and propositional levels. The content of this activity was based on the subject of "Foods and Their Properties" and two learning outcomes in this subject. Beginning of the study, the groups had no significant difference in the cognitive structure to related subjects in terms of conceptual knowledge and propositions. Nevertheless, at the end of the instructional process, there was no significant difference in conceptual remembering between the groups, but a significant difference was observed in creating meaningful propositions between concepts.

It was observed that the experimental group improved in writing meaningful propositions, whereas they had a decrease in terms of unrelated propositions in their cognitive structure. However, the control group did not improve statistically significantly. Accordingly, word cloud activities were beneficial for students in terms of acquiring essential concepts of the subject and associating them. Similarly, in the literature, word clouds were reported to improve students' skills contributing to their cognitive structures, such as remembering words and keeping them in memory (Afurobi et al., 2015; DeNoyelles & Foster, 2015; Miley & Read, 2011; Talang &

Mahmoodi, 2013; Yıldız, 2015). According to the literature, the use of Web 2.0 tools in educational environments contributes in various ways to the instructional process (Batıbay & Mete, 2019; Horzum, 2010; Mansouri, 2015; Talang & Mahmoodi, 2013). Moreover, studies on word clouds as a Web 2.0 tool have shown that this activity makes the course more enjoyable and motivates students to learn while also being an easy tool to support learning, as highlighted by Miley and Read (2011). The present study revealed that the Web 2.0 tool provides ease of use and positively influences their learning process allowing primary school students to create word clouds independently. Additionally, it has been found that students have improved their ability to establish meaningful connections between biology concepts and terms during the science course.

Suggestions

The study included the process of students' creating a word cloud in the WordArt application using important words or concepts. The results related to this activity revealed that primary school students were able to easily use the appropriate Web 2.0 tool after becoming familiar with it. Students could be introduced to these tools at different stages of the instructional process, and these could be used for teaching purposes. In this sense, teachers can use appropriate word cloud applications, implement these activities in other subjects and courses, and contribute to the education process in terms of different criteria. In addition, researchers could contribute to the literature by investigating these processes in terms of different variables. As part of this context, their effects on different variables such as creative thinking, critical thinking, and design skills should also be analyzed besides the students' cognitive structures. Another usage area of word clouds was the opportunity to develop different teaching materials by teachers or for teachers. Relatedly, investigating the effects of these ready materials on students would contribute to the literature.

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