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The Effect of Teaching with Web 2.0 Tools on Mathematics Achievement and Retention

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Abstract

This study aimed to examine the impact of using Web 2.0 tools in teaching algebraic expressions to 6th-grade students on their mathematical achievement and retention. In the research, a quasi-experimental design was used with pre-test post-test control group, one of the quantitative research methods. The research was conducted in the 2023-2024 academic year with 88 students, 44 in the experimental group and 44 in the control group, studying in the 6th grade of a public school in Yenimahalle District of Ankara. The experimental group received instruction through Web 2.0 tools for three weeks, while the control group followed the textbook-based curriculum during the same period. In the study, the "Algebraic Expressions Achievement Test" was used to determine academic success. SPSS 22.0 program was used to analyze the data. Independent Samples t-test, Repeated Measures ANOVA, and Benferroni multiple comparison test were used in the analysis process. The findings indicated a significant difference in the post-test mean scores of algebraic expressions between the experimental and control groups, favoring the experimental group. In conclusion, the use of Web 2.0 tools in teaching algebraic expressions was found to be more effective in enhancing students' academic achievement and retention compared to current teaching methods.

***Keywords*:** Web 2.0 tools, algebraic expressions, educational tools, mathematics.

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Web 2.0 Araçlarıyla Öğretimin Matematik Başarısına ve Kalıcılığa Etkisi

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Öz

Bu araştırma, 6. sınıf cebirsel ifadeler konusunun öğretiminde web 2.0 araçları kullanımının öğrencilerin matematik başarısına ve kalıcılığa etkisini incelemek amacıyla gerçekleştirilmiştir. Araştırmada nicel araştırma yöntemlerinden ön test son test kontrol gruplu yarı deneysel desen kullanılmıştır. Araştırmaya 2023-2024 eğitim öğretim yılında Ankara ilinin Yenimahalle ilçesindeki bir devlet okulunun 6. sınıfında öğrenim gören 44 deney, 44 kontrol grubu olmak üzere toplam 88 öğrenci katılmıştır. Deney grubu öğrencilerine 3 hafta boyunca web 2.0 araçlarıyla eğitim gerçekleştirilirken kontrol grubu öğrencilerine bu süre boyunca ders kitabına uygun şekilde ders işlenmiştir. Araştırmada akademik başarıyı belirleyebilmek için "Cebirsel İfadeler Başarı Testi" kullanılmıştır. Verilerin analizinde SPSS 22.0 kullanılmıştır. Analiz sürecinde Bağımsız örneklemler t-testi, Tekrarlı Ölçümler ANOVA testi ve Benferroni Çoklu Karşılaştırma testi kullanılmıştır. Elde edilen bulgular, deney grubunun cebirsel ifadeler son test ortalamaları açısından kontrol grubuna gore anlamlı bir fark olduğunu göstermiştir. Sonuç olarak, matematik dersinde cebirsel ifadelerin öğretiminde Web 2.0 araçlarının kullanımının mevcut öğretime kıyasla öğrencilerin akademik başarılarını artırdığı ve öğrenmenin kalıcılığı üzerinde daha etkili olduğu belirlenmiştir.

***Anahtar Sözcükler*:** Web 2.0 Araçları, cebirsel ifadeler, eğitim araçları, matematik.

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Introduction

Science and technology have been affecting every aspect of human life and the socio-economic condition of society since the last quarter of the 20th century (Ersoy, 1997). As a result of this effect, there is a greater need for adequate and quality information than ever before. At this point, the advancement of technology can greatly facilitate our access to information.

The contemporary understanding of education today focuses not on merely delivering information but on the structuring of knowledge through student-centered education. This approach, where the teacher acts as a guide, has caused concepts such as educational technology to evolve. Thanks to this change in educational technology, education can reach a wider audience. The teaching process has become more efficient, where individual needs are analyzed and the continuity of programs is ensured. This approach enhances the effectiveness and performance of educators, providing education suitable for the student's ability while controlling environmental factors (Batdal and Avcı, 2007).

Mathematics is generally seen as a difficult subject (Baki, 2002). This is because it contains abstract concepts by its nature. Therefore, there is a need for concretization in its teaching. Technology provides us with conveniences in concretizing mathematics. It offers simulation programs that can easily bring situations that are difficult and costly to bring to the classroom environment (Ankay, 2019). Educational technologies are important in transforming abstract concepts and difficult-to-understand topics in mathematics into daily life skills. Additionally, the goal of mathematics education is to positively develop students' attitudes, increase their participation levels, and enable them to establish relationships between concepts by improving reasoning and problem-solving skills. It is believed that using educational platforms in lessons will provide lasting and meaningful learning (Akbaş, 2019). The use of instructional technologies facilitates the transmission of the formal structure of mathematical activities and makes it easier to focus on reasoning, reflective thinking, and problem-solving skills (Tutak, Birgin, and Türkdoğan, 2009).

Algebra is one of the most important topics in mathematics. However, algebra is not easily understood by students. This is due to the structure of algebra, the students' mental development (readiness), and deficiencies in algebra teaching (Dede and Ergün, 2003). Educators try to help students make sense of algebra's abstract structure by using different methods and techniques in algebra teaching. Despite the many different methods available in algebra teaching, the most commonly used method is the traditional one. In teaching this topic, which has a connection to daily life, most methods rely on memorization. It is important for teachers to teach algebra to students in a way that ensures long-term retention (Kitt and Leitze, 1992).

In the national education program, emphasis is placed on algebraic thinking studies, which are part of mathematical thinking, in the algebra learning area, which is one of the basic topics of mathematics. Achievements have been prepared by examining national and international studies in this area. According to the program, the first achievements in the field of algebra are included in the 6th grade. At this grade level, students are expected to make sense of algebraic expressions. By the 7th grade, the goal is for students to perform operations with algebraic expressions, understand the concept of equality, and solve equations. At the 8th grade level, the concept of algebra is addressed in a much broader way, covering algebraic expressions, identities, linear equations, and inequalities (Ministry of National Education [MoNE], 2018).

Today, the best examples of the combination of education and technology are Web 2.0 tools. Web 2.0 tools are not a site or structure. It is a concept that encompasses all sources and developments with certain characteristic features. The term Web 2.0 was first used in a brainstorming session planned by O'Reilly and Media Live International in 2004 (Bozkurt, 2013). Web 2.0 tools provide an interactive environment by enabling user participation. Web 2.0, which we can explain as the advanced version of Web 1.0, creates a learning environment based on problem-solving strategies, especially in mathematics (Bülbül and Taş, 2023). Web 2.0 tools create learning environments with a constructivist approach in teaching. There are many domestic and international Web 2.0 tools that can be used in mathematics education (Conole and Alevizou, 2010). The most well-known among these are EBA, GeoGebra, Wordwall, MorpaCampus, Learningapps, Matific... The Education Informatics

Network (EBA) was created with a joint effort by the Ministry of National Education and the General Directorate of Innovation and Educational Tecnologies. EBA aims to create different, rich teaching environments for teachers and students. EBA contains many teaching materials prepared online, such as content, books, videos, visual elements, animations, interactive activities, tests, exams, etc. (EBA, 2016). The presence of many such applications facilitates the teaching process. In addition to education, games, cartoon, and animation applications, which aim to help students follow the process more carefully, are also among Web 2.0 tools. It is believed that these Web 2.0 tools will enable even relatively difficult topics like algebra to be learned in a fun and meaningful way.

When examining the studies conducted, it is generally seen that the effect of the use of EBA and GeoGebra on success is investigated. İçel (2011) examined the effect of GeoGebra on success in the topic of Triangles and Pythagorean Theorem in the 8th grade in his research. According to the data obtained with the achievement test, it was concluded that GeoGebra has an effect on academic success and retention. Öz (2015) examined the effect of using GeoGebra 5.0 in teaching the sub-learning area of Geometric Objects to 7th grade students on student success in his study. As a result of the research, it was seen that teaching with GeoGebra increased academic success. Şeker and Erdoğan (2017) examined the effect of GeoGebra on success and self-efficacy in Geometry teaching in their research. At the end of the research, it was revealed that GeoGebra increased course success and self-efficacy. Açıkgöz (2018) examined the effect of teaching with the Education Informatics Network (EBA) on academic success in the topic of Views of Objects from Different Directions in the 7th grade in his study. According to the results obtained, it was seen that teaching with EBA increased academic success and provided permanent learning. It was also stated that students had a positive attitude towards mathematics. Kelismail (2019) examined the effect of teaching with the Education Informatics Network (EBA) on academic success in the teaching of algebraic expressions in the 6th grade in his research. As a result of the research, it was seen that EBA did not have an effect on academic success but had an effect on retention. In addition, it was determined that there was no difference in students' attitudes. Polat (2023) examined the effect of Web 2.0 tools on academic success in the teaching of algebraic expressions in his research. According to the data obtained, it was seen that Web 2.0 tools increased academic success and developed a positive attitude towards mathematics.

When examining the studies in the literature, no study has been found that investigates the effect of a teaching environment created with Web 2.0 tools on students' mathematics success and retention together. Therefore, it is thought that this study will contribute to the literature. The aim of this research is to examine the effect of using Web 2.0 tools in the teaching of algebraic expressions on the mathematics success and retention of 6th grade students. In line with this aim, answers will be sought for the following sub-problems:

- Is there a significant difference between the post-test mean scores of algebraic expressions of the experimental and control groups?
- Is there a significant difference between the post-test mean scores of algebraic expressions of the experimental and control groups?
- Is there a significant difference between the post-test mean scores of algebraic expressions of the experimental and control groups?
- Is there a significant difference between the retention test mean scores of algebraic expressions of the experimental and control groups?

Method

Research Design

In this study, which investigates the effect of a teaching environment created with Web 2.0 tools on students' achievement and retention in the topic of algebraic expressions in the 6th-grade mathematics course, a quasi-experimental design with a pre-test post-test control group, one of the quantitative research methods, was used. The quasi-experimental design shows the difference in change between the two groups (Büyüköztürk, 2008). This design was used to observe the difference between the experimental and control groups in the study.

Participants

The sample of the study consists of 6th-grade students from a public middle school in Yenimahalle district of Ankara during the 2023-2024 academic year. In this study, conducted in a public school affiliated with the Ministry of National Education, two out of four 6th-grade classes were randomly selected as the experimental group, and the other two were designated as the control group, with no changes made to the class compositions. The study utilized cluster sampling, one of the non-random sampling methods, and included a total of 88 students, comprising 44 in the experimental group and 44 in the control group, all of whom participated with parental consent.

Data Collection Tools

The data in the study were measured using the "Algebraic Expressions Achievement Test." This test was administered to both groups as a pre-test, post-test, and retention test.

Algebraic Expressions Achievement Test

In this study, the "Algebraic Expressions Achievement Test" developed by Okuducu (2020) was used. This achievement test was prepared in accordance with the questions in the 6th-grade mathematics textbook. The Algebraic Expressions Achievement Test includes three outcomes in the 6th-grade algebra sub-learning area specified in the Mathematics Teaching Program of the Ministry of National Education (MoNE, 2018). The test consists of ten questions for each outcome, making a total of 30 questions. While preparing this test, feedback was obtained from three middle school mathematics teachers with 13-17 years of experience working at MoNE and experts in the field of measurement to ensure its reliability (Okuducu, 2020). The pilot implementation of the test was conducted with 150 7th-grade students studying at a public middle school. As a result of the item analysis, three items were removed from the test because their discrimination was less than 0.20 (Metin, 2015). After necessary corrections, the Algebraic Expressions Achievement Test was finalized as a test consisting of 27 questions. The item distribution of the test according to the final outcomes is shown in Table 1.

Table 1. *6th grade algebraic expressions test learning outcomes and associated items*

Learning Outcomes	Item Numbers
1. Writes an algebraic expression suitable for a given verbal situation and writes a verbal situation suitable for a given algebraic expression.	1, 2, 3, 4, 7, 11, 17, 22, 24
2. Calculates th evalue of an algebraic expression for different natural number values of the variable.	5, 6, 10, 15, 18, 19, 21, 25,27
3. Explains the meaning of simple algebraic expressions.	9, 12, 13, 14, 16, 20, 23, 26

Data Collection Process

Before starting the implementation, the "Algebraic Expressions Achievement Test" was administered as a pre-test to both groups. Based on the results obtained, there was no statistically significant difference in achievement between the groups, so the groups were randomly assigned as experimental and control groups. The same teacher conducted the 'Algebra' learning area over three weeks using Web 2.0 tools prepared materials for the experimental group, while the control group received instruction via the presentation method using the textbook in accordance with the MoNE mathematics teaching program. For the experimental group, slides containing links to Web 2.0 tools were shown on the smart board for each learning outcome.

During the implementation process, pre-made activities from Web 2.0 tools such as MorpaKampüs, Baamboozle, EBA, Matific, Quızızz, Transum, Visnos, and GeoGebra were used. Students were asked to complete the online test at the end of each slide. For the control group, the lessons were conducted using the presentation method with the mathematics textbook prepared by the Ministry of National Education. No smart board or Web 2.0 tools were used during the lesson. Exercises in the textbook were solved. The instruction for both groups lasted for three weeks (15 class hours). After the implementation, the same achievement test was administered as a post-test to students in both groups. Three weeks after the end of the implementation process, the same test was administered to both groups as a retention test.

Data Analysis

All data in this study were analyzed using the SPSS 20 software package. When the study group is smaller than 50, the Shapiro-Wilk test is used to determine whether the data are normally distributed, with $p > .05$ indicating a normal distribution (George and Mallery, 2010). Since the data showed a normal distribution according to the Shapiro-Wilk test, the analysis was conducted using parametric tests. For the comparison of two independent groups, the Independent Sample t-test was used. For comparing more than two related groups, the Repeated Measures ANOVA test was utilized. To determine which groups had statistically significant differences, the Bonferroni Multiple Comparison test was applied.

Ethics Committee Statement

This study was conducted with the approval number 14/130, obtained during the meeting of the Ethics Committee of Ankara University on 06.05.2024.

Results

In this section, the analyses of the data obtained from the achievement test conducted with the experimental group, which received instruction with Web 2.0 tools, and the control group, which received instruction with the existing teaching method in the 6th-grade algebraic expressions topic, are examined for each sub-problem of the research.

First, the independent samples t-test was used to analyze whether there was a significant difference between the pre-test scores of the algebraic expressions achievement test for the experimental and control group students. The results of the analysis are presented in Table 2.

Table 2. *T-test results for pre-test scores on algebraic expressions achievement test*

Group	N	$\bar{X}$	S	df	t	Sig.
Experimental	44	9.80	2,68	75	1.07	0.29
Control	44	9.02	3,95			

When Table 2 is examined, there is no statistically significant difference in the pre-test average scores of the experimental and control groups in terms of algebraic expressions proficiency test, $t(75) = 1.07$, $p > .05$. This finding can be interpreted as initially both groups being equivalent in terms of mathematical achievement.

To investigate the first sub-problem of the study, 'Is there a significant difference between the average scores of algebraic expressions in the final test between the experimental and control groups?' the data were analyzed using an independent samples t-test. The analysis results obtained are provided in Table 3.

Table 3. *T-test results for post-test scores on algebraic expressions achievement test*

Group	N	$\bar{X}$	S	df	t	Sig.
Experimental	44	20,61	5,17	81	2,61	0,01
Control	44	17,34	6,52			

When Table 3 is examined, a statistically significant difference is observed between the mean scores of algebraic expressions achievement test post-tests for the experimental and control groups ($p<.05$). According to the obtained data, it can be said that the experimental group students show higher achievement than the control group students, as the mean score of the post-test for the experimental group ($X=20.61$) is higher than that of the control group ($X=17.34$), indicating that teaching with web 2.0 tools is more effective than the current method.

To address the second sub-problem of the study, which is 'Is there a significant difference between the mean achievement scores of the experimental group students in pre-test, post-test, and retention test?', the mean scores of pre-test, post-test, and retention test were compared within the experimental group. Repeated Measures ANOVA test was used for data analysis. The analysis results are provided in Table 4.

Table 4. *ANOVA results for pre-test, post-test and retention test scores in the experimental group*

Source of Varience	Sum of Squares	df	Mean Square	F	Sig.	η^2	Significant Difference
Measurement	3255,68	2	1627,85	399,64	,00	,91	1<2;1< 3
Error	350,30	86	4,07				
Total	3605,98	88					

When examining Table 4, it is evident that the mean scores of algebraic expressions achievement pre-test (X=9.80), post-test (X=20.61), and retention test (X=20.02) for the experimental group students are lower. Through Bonferroni multiple comparison test, it was determined that the post-test average was the highest, with a slight decrease in the retention test compared to the post-test, although this decrease was not statistically significant. Based on the obtained data, it is concluded that the education provided with Web 2.0 tools enhances the achievement of students in the experimental group and that their knowledge remains enduring over time.

To address the third sub-problem of the study, which is 'Is there a significant difference between the mean achievement scores of the control group students in pre-test, post-test, and retention test?', the pre-test, post-test, and retention test scores of the control group were compared. Repeated Measures ANOVA test was utilized for data analysis.

Table 5. *ANOVA results forpre-test, post-test and retention test scores in the control group*

Source of Varience	Sum of Squares	df	Mean Square	F	Sig.	η^2	Significant Difference
Measurement	1551,56	2	775,78	80,60	,00	,65	1< 2, 3 2>3
Error	827,77	86	9,6				
Total	2379,33	88					

When Table 5 is examined, it is observed that the control group students have lower mean scores in algebraic expressions pre-test (X=9.02), post-test (X=17.34), and retention test (X=14.18). According to the results of the Bonferroni multiple comparison test conducted to understand the difference between which measurements, it is seen that pre-test achievement scores are significantly lower than post-test and retention test scores, and retention scores are also significantly lower than post-test scores. It can be said that the current curriculum enhances students' achievement but the retention of knowledge is low.

To answer the fourth sub-problem of the research, which is 'Is there a significant difference between the algebraic expressions retention test mean scores of students in the experimental and control groups?', the retention tests of the experimental and control groups were compared. Independent samples t-test was used for data analysis. The analysis results are presented in Table 6.

Table 6. *T-Test Results for Retention Test Scores on Algebraic Expressions Achievement Test*

Group	N	$\bar{X}$	S	df	t	Sig.
Experimental	44	20,02	5,19	80	4,52	,00
Control	44	14,18	6,82			

When Table 6 is examined, it is observed that the experimental group's retention test average score (X = 20.02) is higher than the control group's retention test average score (X = 14.18). According to the analysis of the data, it can be said that the effect of education with web 2.0 tools on retention is more effective compared to the current curriculum, and students in the experimental group achieve more enduring learning than those in the control group.

Discussion, Conclusion and Recommendations

The aim of this study was to investigate the impact of teaching 6th-grade algebraic expressions using web 2.0 tools on mathematics achievement and retention. The analyses of the data in the study revealed that initially, the experimental and control group students were equivalent in terms of achievement. When the experimental and control groups were examined separately, both groups

showed an increase in academic achievement after the pre-test. However, the experimental group showed a greater increase, thus being more successful than the control group. Based on these findings, it can be said that teaching mathematics with web 2.0 tools is more effective in terms of academic achievement compared to the current teaching method. A decrease in the retention test after 3 weeks was observed in the control group, indicating that some of the information was forgotten for these students. No statistically significant difference was found between the academic achievement of the experimental group in the post-test and retention test. Therefore, it was concluded that mathematics instruction with web 2.0 tools for the experimental group was enduring. Similar results were also found in Polat' s (2023) study. The findings of this study align with previous research examining the impact of web 2.0 tools on academic achievement in teaching algebraic expressions. Research in the literature has mostly focused on GeoGebra and EBA. Kelismail (2019) stated in his study examining the effect of EBA-supported teaching of 6th-grade algebraic expressions on achievement and retention that there was no significant difference in the average final test scores but noted an effect on retention. The results of this study do not parallel our research. However, there are also studies indicating that EBA-supported instruction increases academic achievement (Açıkgöz, 2018; Gürler, 2021; Haskanlı, 2021; Vahit, 2019). Similarly, in the literature, there are studies examining the effect of GeoGebra on academic achievement, with positive outcomes (İçel, 2011; Ünlütürk, 2016; Bayrambeğ, 2021; Küçük, 2019; Şeker & Erdoğan, 2017; Zengin, 2019). The differences in research results are predicted to stem from variations in the topics studied, separate use of web 2.0 tools, use of these tools at certain stages of the lesson, and differences in the academic achievement levels of students in the research.

Despite the benefits of using web 2.0 tools in mathematics education, there are also some disadvantages. The overcrowding of existing classrooms limits the opportunity for each student to participate individually. Inadequate technological infrastructure and lack of sufficient materials or technical glitches disrupt the flow of the lesson. It has been observed that students' attention is diverted when web 2.0 tools are opened on smartboards/computers. Although sending assignments online facilitates assignment monitoring, not every student could access the assignments due to technical issues.

During the implementation phase of the research, the inadequacy of Turkish web 2.0 tools suitable for mathematics education was observed. It is considered necessary to provide support for creating Turkish content. It is predicted that students, teachers, and parents need to be informed to teach web 2.0 tools. In today's rapidly evolving technology, web 2.0 tools not only create new learning opportunities for students but also enable students to be content creators, not just consumers. Therefore, increasing the number of studies conducted with web 2.0 tools and researching how to better utilize these tools becomes important.

In experimental studies utilizing non-random sampling methods, initial differences between groups may affect the results. To counter selection bias in such research, the initial equivalence of groups should be verified by comparing their pre-test scores. To address this issue, which negatively impacts internal validity, this study employed random assignment for the experimental and control groups, aiming to ensure internal validity. Additionally, the administration of pre-tests, post-tests, and retention tests in the study may increase students' familiarity with the tests, which could influence the results. To minimize the test effect, sufficient intervals between tests should be provided, and tests should be conducted using different but equivalent measures rather than the same ones. This recommendation aims to prevent students from becoming accustomed to the tests, thereby reducing their impact on the results. In this study, sufficient intervals between tests were provided to address this issue. Another factor threatening internal validity is the inconsistent implementation of experimental interventions for all participants. To prevent this, a standardized protocol was followed throughout the instructional process in both the experimental and control groups, ensuring that the experimental intervention was carried out according to this protocol. With all these measures, it can be stated that internal validity was achieved in this study. Furthermore, it is recommended that this research be replicated with samples from different schools, geographic regions, and socio-economic levels to examine how the use of Web 2.0 tools is influenced by varying school environments and teaching conditions. Conducting experimental studies with larger sample groups can enhance the

generalizability of the findings. All these considerations are important for ensuring external validity in similar future studies. Additionally, the long-term effects of Web 2.0 tools should be evaluated by monitoring students' academic achievement and retention results in subsequent years. In conclusion, researchers can obtain more robust and reliable results by being aware of threats to internal and external validity and developing strategies to minimize these threats. It is believed that these recommendations can guide future research and educational practices.

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