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How to use Excel to teach fractions?

Fahrettin Aşıcı [a] *, Cengiz Çinar [b]

[a] Balikesir University, Türkiye.
[b] Gazi University, Türkiye.

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Highlights

- It is important to offer a fresh perspective on Excel, a program that is widely used across the globe.
- The use of Excel to teach fractions had a positive effect on achievement and attitude.
- Although the Excel worksheets were effective in terms of achievement, the improvement in attitudes was limited.
- It is difficult to change attitudes towards mathematics with short-term activities.

Article Info: Research Article

Keywords: *Excel, Mathematics, Fractions, Attitude, Academic Achievement*

Abstract

This study aimed to examine the effect of using Excel in teaching fractions in a 6th grade mathematics course on students' academic achievement and attitudes. To achieve this, a quasi-experimental design with a pretest-posttest control group was implemented. The research involved 62 students from a public secondary school in a central province of eastern Turkey over a period of 12 class hours (3 weeks). Prior to the study, experimental and control groups were randomly assigned, and efforts were made to balance the groups based on various factors (e.g., pass marks, pretest scores). A mathematics achievement test (MAT) comprising 18 multiple-choice questions, and a 20-item mathematics attitude scale (MAS) were employed to collect data. The experimental group was taught using the Excel program, while the control group received instruction via traditional teaching methods outlined in the curriculum. Data collected after the intervention were analyzed using t-tests in the SPSS program. The results revealed a significant improvement in the academic achievement of the experimental group compared to the control group, indicating the effectiveness of using Excel-based teaching materials. Additionally, both groups showed positive changes in their attitudes towards mathematics; however, no significant difference was found between the groups in terms of the impact of the teaching method on students' attitudes.

1. Introduction

Today, the rapid advancement of technology has triggered significant changes and transformations in the field of education (Özen & Kurtuluş, 2023). It is especially important that technology transforms the abstract and complex nature of education into something concrete and meaningful. Providing education in a stimulating, efficient, and high-quality manner has become nearly impossible without the use of technological methods (Babapour Golezani, 2012). The fresh dynamics that computers have brought to communication and social interaction are evident across various domains. Computers have become indispensable in modern life, serving a broad spectrum of functions—from data input, processing, and output in complex systems to the operation of relatively simple applications. It is unthinkable to view computers, which are so integral to today's world, as separate from the educational realm (Yenilmez & Ersoy, 2008). Therefore, it can be said that every field of education is impacted by the movement of technology and digitalization, though in varying dimensions and areas (Temel & Gür, 2022).

* Corresponding author. Department of Mathematics Education, Necatibey Faculty of Education, Balikesir University, Türkiye
e-mail addresses: fahrettin.asici@balikesir.edu.tr, ccinar2525@gmail.com
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The integration of computers into education has given rise to computer-assisted instruction. The incorporation of this technology into schools and the adoption of computer-supported teaching methods have solidified the concept of computer-assisted instruction (Taşlıbeyaz, 2010). Uşun (2013) defined computer-assisted instruction as “a teaching method where the computer serves as a learning environment within the classroom, enhancing both the teaching process and student motivation”. This method allows students to learn at their own pace, integrating self-learning principles with computer technology. Although computer-assisted instruction is a complex approach that demands skills, labor, and financial investment-such as training teachers, selecting appropriate hardware, and providing courseware aligned with the curriculum-it is gaining traction in many countries daily, despite the challenges of implementation (Alkan, 1986). Through computer-assisted instruction, abstract concepts that are challenging for students to grasp are enhanced and made more tangible through visual and auditory means. Consequently, the impact of computer-assisted instruction on mathematics teaching is expected to be highly significant.

The ability to project mathematical formulas, relationships, and procedures onto the screen has enabled symbolic and graphical transitions that enhance analytical understanding (Hangül, 2010). In their 2003 study, Güven and Karataş stated, “The appropriate use of computers in mathematics education should involve helping students develop high-level cognitive skills and allowing them to construct their own mathematics by providing them with experiences similar to those of a mathematician”. In this regard, the technologies used in mathematics education can be grouped under three main categories (Köse-Yavuzsoy, 2008):

i. *General technological tools*: These are tools that encompass all forms of technology, not limited to mathematics instruction. An example would be web-based communication platforms.
ii. *Technological tools for doing mathematics*: This category includes technologies designed to simplify mathematical tasks and enhance accuracy, such as hand-held calculators, computer software like Excel, statistical programs, and graphing tools.
iii. *Technological tools for teaching mathematics*: These are software programs specifically developed to enhance students' understanding of mathematical concepts, such as Cabri 3D, Geometry Sketchpad, and GeoGebra.

Similarly, Baki (2002) categorized the cognitive tools and software used in computer-assisted instruction as dialogue-based software, spreadsheets, simulations, microworlds, hypermedia, and Internet resources.

As evident, there are various types of technological tools and software that can be utilized in mathematics teaching, as it is an area where computer-aided applications are actively employed and should be further integrated. While these tools and software can significantly enhance the teaching and learning environment, challenges may arise in promoting their widespread use. In this regard, Microsoft Office Excel, a widely used electronic spreadsheet software, could be a valuable computer-assisted teaching tool in mathematics instruction. This is because Excel has been cited as an effective means to address the limitations of traditional teaching approaches (Özüsağlam et al., 2009).

Spreadsheets are software tools designed to organize and manage data, perform analyses, and generate relevant graphs when needed (Arslan, 2006). They offer significant advantages for calculations and graphical representations. Examples include Lotus and Excel (Baki, 2002). Spreadsheets serve as powerful mathematical resources, providing students with open, exploratory environments that encourage independent research and inquiry (Dede & Argün, 2003).

Excel, developed by Microsoft, is a program designed to operate on Microsoft Windows and Apple Macintosh operating systems. It is currently the most widely used software of its kind globally, thanks to its tabulation and graphing capabilities, its ability to perform detailed financial analyses, and its integration of the Visual Basic macro programming language for custom applications. There are several versions released over the years, specifically for the Windows operating system (Wikipedia, 2024). With its extensive library of arithmetic, statistical, logical, and financial functions, Excel can retrieve data from large database systems in various formats and transform this information into organized tables and graphs (Monk et al., 2012). As an advanced computational tool, it is used for diverse tasks such as calculations, graphing, program development, and statistical analysis. Excel is not only valuable in education but also essential for streamlining operations in businesses, schools, hospitals, markets, and numerous other professional environments (Bayraktar, 2008).

In this regard, Excel offers a highly versatile library for exploring mathematical concepts. Beyond creating algebraic and graphical representations, it also supports mathematical modeling (Zengin, 2011). Iterative arithmetic operations, statistical tables, and graphs can be generated with ease and efficiency (Baki, 1996). Due to its robust features, this software significantly reduces the time and effort needed for complex paper-and-pencil calculations, completing them quickly and without errors (Baki, 2002). Additionally, users can enter desired formulas using Excel's built-in commands without the need for programming, allowing them to see instant results. This functionality makes it easier to grasp the mathematical methods or algorithms under study (Baki, 2000).

Although Excel may appear to be a tool reserved for complex computations by adults, it can actually be used in engaging and creative ways, offering great potential for students of all ages and across various curriculum areas (Beck et al., 2014). Through Excel applications, students are relieved from complex algebraic operations and calculations, enabling them to instantly verify the accuracy of their results. This shift allows students to focus more on understanding mathematical structures and their applications. Consequently, they have the opportunity to work in a more flexible environment, actively engage in problem-solving, and develop innovative solutions (Özüsağlam et al., 2009).

The Excel program is suitable for use in teaching due to several factors:

- Many teachers and students are already familiar with it (Bozkurt & Cilavdaroğlu, 2011; Yavuz & Can, 2010).
- It is readily available on most school computers.
- It provides instant results for both students and teachers.
- It allows students to immediately observe changes when variables are modified (The National Centre for Technology in Education & Project Maths Development Team, 2010).

However, Excel and similar software can only be used effectively if a shared mathematical language is established between the teacher and the student. Given its widespread use among computer-literate individuals, Excel has the potential to be integrated into teaching more rapidly. For instance, the benefits of using Excel in algebra instruction include enhanced communication, symbolic representation, and organization, as well as enabling new actions such as calculation, visualization, interactivity, and demonstrations across various domains. Thus, Excel is considered a tool that not only facilitates the transition from arithmetic to algebra but also simplifies the development and application of algebraic methods (Yavuz & Baştürk, 2008).

1.1. Literature

A review of the literature reveals a limited number of studies examining student and teacher perspectives on the use of Excel in mathematics instruction, its impact on student achievement, and the effectiveness of materials designed for this purpose (Aksoy et al., 2012; Bayraktar, 2008; Birgin & Kutluca, 2007; Birgin et al., 2008; Budak, 2000; Erbaş, 2005; Işıksal & Aşkar, 2005; Kutluca, 2009; Kutluca & Birgin, 2007; Neurath & Stephens, 2006; Nwabueze, 2006; Özdemir Erdoğan & Turan, 2014; Öztekin, 2001; Peker & Bağcı, 2008; Stephens, 2003; Yavuz & Baştürk, 2008). The high usability and effectiveness of the Excel program in mathematics teaching environments is evident, demonstrating its strong potential in this area. However, the literature also includes studies that investigate the use of Excel in learning and teaching environments across various other fields (El-Awad & Elseory, 2012; Duller, 2008; Dell'omodarme & Valle, 2006; Christensen & Stephens, 2003):

In their study, Aksoy, Çalık, and Çinar (2012) examined the impact of teaching with Excel on the ability of first-year teacher education students to draw graphs of functions. The findings indicated that students had positive opinions about using Excel for instruction, and that it significantly improved their achievement.

Birgin, Kutluca, and Gürbüz (2008) conducted a study with 43 seventh-grade students to investigate the effect of computer-assisted instruction on academic achievement. The study focused on the topic "Coordinates of a Point in the Plane and Line Graphs," as part of the seventh-grade primary school curriculum, using materials developed with the programs "Excel" and "Coypu." The results indicated that the computer-assisted teaching method was more effective in enhancing student achievement compared to traditional teaching methods.

Nwabueze (2006) investigated the effect of using Excel and the Internet in teaching algebra on the performance of undergraduate students. One group received technology-enhanced instruction, while the other group was taught using traditional methods. By the end of the study, positive gains in both student achievement and attitudes were observed, with no gender differences identified.

Kutluca (2009) studied the effects of a constructivist, computer-supported learning environment on students' cognitive and affective learning, specifically for teaching quadratic functions in 10th-grade mathematics. Using Coypu, Derive, and Excel software, the research found that students' academic achievement and attitudes towards mathematics improved. Moreover, students adapted well to and enjoyed the new learning environment.

Neurath and Stephens (2006) investigated the impact of using an Excel program on high school students' performance in algebra. The study's results indicated that the use of Excel had a positive effect on student achievement. Öztekin (2001) conducted a study with the goal of developing computer-assisted mathematics teaching materials for graphing first- and second-order functions using the Excel program. Similarly, Işıksal and Aşkar (2003) aimed to develop worksheets using spreadsheets and dynamic geometry software to solve problems related to first-order equations with one unknown, symmetry, coordinate systems, and line graphs in mathematics courses.

1.2. Purpose and Significance of the Study

The most crucial factor for the effective use of computers in teaching and learning environments is the software employed. A review of the literature reveals numerous studies examining the effectiveness of various software applications used in mathematics instruction, such as GeoGebra, Geometer's Sketchpad, Logo, Cabri, Coypu, and Derive.

It is essential to adopt student-centered approaches when utilizing educational technologies and to encourage active student participation in the learning process. By doing so, educational technologies can enhance students' learning experiences, enrich teaching practices, and contribute to the overall success of educational institutions (Orak & Turan, 2024). According to Keser (1988), a key prerequisite for the success of computer-assisted instruction is that the course software should be easy to understand, flexible, and compatible across different computers. The factors contributing to the success of computer-assisted instruction applications can be listed as follows (Uşun, 2013): i. Selection of appropriate hardware, ii. Development and evaluation of courseware, iii. Teacher training, iv. Integration of computer-assisted instruction into the curriculum and school environment, v. Ongoing monitoring, measurement, and evaluation.

Among the various elements, courseware is considered the most prominent, with the success of computer-assisted instruction being directly linked to its effectiveness (Uşun, 2013). The quality of the courseware and its alignment with educational programs are viewed as critical aspects of the computer-assisted instruction process (Aşkar et al., 1993). Even if the best hardware and the most skilled teacher are present, the software serves as the integrating factor (Arslan, 2003). In this regard, it is important to investigate the impact of Excel, one of the most widely used programs globally and known for its ease of use compared to other software, on academic achievement and attitudes in mathematics education.

A review of studies on computer-assisted instruction in mathematics teaching revealed that research specifically examining the effectiveness of Excel in mathematics education is limited. In this regard, the current study is important for highlighting the gap in literature, addressing the shortcomings identified in previous research, and serving as a valuable resource for future studies.

The topic of fractions, which will be taught in this study, is a fundamental and critically important subject for students. Fractions are not only used in assessments across various fields of expertise, but they are also essential for understanding algebra and more advanced mathematics (Van De Walle vd., 2013). As one of the most abstract topics in middle school mathematics, fractions form the foundation for many areas in the curriculum, including decimal fractions, rational numbers, ratio, and proportion (Arslan-Kılcan, 2006). In this regard, the study is valuable for examining the impact of Excel software in teaching fractions and determining whether it can improve students' attitudes towards the subject.

The aim of this study is to examine the effect of using Excel in teaching fractions on the academic achievement and attitudes of 6th-grade middle school students, compared to traditional teaching methods in mathematics. Accordingly, the research problem has been defined as: "What is the effect of using Excel to teach fractions in the 6th-grade mathematics course on students' academic achievement and attitudes?"

To address the main problem outlined above, the study seeks to answer the following sub-questions:

Fig. 1. Sub-questions (EG: Experimental Group, CG: Control Group)

2. Methodology

2.1. Research Model

Since this study investigated the effect of teaching fractions with Excel on students' academic achievement and attitudes, the experimental method was used. However, since the school's current conditions prior to the research process did not allow for random assignment of students into groups, a quasi-experimental design was employed. Specifically, the pretest-posttest matched control group design was utilized with the existing groups. In this design, two pre-existing groups are matched based on specific variables without using unbiased assignment. The matched groups are then randomly assigned to the treatment conditions (Büyüköztürk et al., 2012).

The groups in the study were selected to be as equal as possible by considering their general academic achievements from previous years. These groups were then randomly assigned as experimental and control groups. Pre-tests were administered to assess the groups' prior knowledge in fractions and their attitudes. During the application, the experimental group was taught using activities prepared with the help of Excel, while the control group continued with the standard teaching methods. The researcher conducted the teaching for both the experimental and control groups.

2.2. Study Group

The study was conducted with 62 students from a public secondary school in the center of a province in the Eastern Anatolia region of Turkey, spanning 12 lessons over 3 weeks. “The experimental group” (EG) included 31 students (14 boys and 17 girls), and “the control group” (CG) comprised 31 students (18 boys and 13 girls). The selection of this school for the study was influenced by the willingness of the school administrators and mathematics teachers to participate, as well as the convenient transport and working conditions for the researcher. All necessary permissions were obtained prior to conducting the research.

The study utilized pre-existing groups, considering the school’s current situation and curriculum. Administrators and mathematics teachers were consulted regarding which groups to use. Based on the information (opinions of teachers and administrators, students' performance in mathematics in grades 4 and 5) gathered, it was determined that classes 6-A and 6-C were equivalent. Statistical analysis of the pre-test results from the achievement test administered to both classes, along with the students' grade point averages from grades 4 and 5, confirmed that these classes were appropriate and equivalent for the research (see Table 1 and Table 2).

Table 1.

t-Test Results for the 4th Grade GPAs of EG and CG Students

Group	N	$\bar{X}$	S	t	sd	p
EG	31	87.41	9.24	1.805	60	0.076
CG	31	82.66	11.37			

As shown, the average grade point average (GPA) for EG is 87.41, while CG average is 82.66. The t-test conducted to determine whether there was a difference between the grade point averages of the groups revealed no statistical difference between them [$t(60) = 1.805$, $p > .05$].

Table 2.

t-Test Results for the 5th Grade GPAs of EG and CG Students

Group	N	$\bar{X}$	S	t	sd	p
EG	31	88.96	8.03	1.642	60	0.106
CG	31	85.13	10.19			

As shown in Table 2, the mean GPA of EG students is 88.96, while CG students have a mean GPA of 85.13. The t-test results indicate that there is no difference between the GPAs of the groups [$t(60) = 1.642$, $p > .05$].

Based on the results obtained, it can be concluded that classes 6-A and 6-C, selected as EG and CG, are similar in terms of academic achievement and are therefore suitable for the study.

2.3. Data Collection Tools

In this study, quantitative data were collected using the "Mathematics Achievement Test" and the "Mathematics Attitude Scale," both designed specifically for the topic of fractions in the mathematics course.

2.3.1. Mathematics Achievement Test (MAT)

In the study, the "Mathematics Achievement Test," consisting of 18 multiple-choice questions designed to assess students' achievement in mathematics, was administered twice—once as a pre-test and once as a post-test. This test was originally prepared by Nuri Can Aksoy for his 2010 master's thesis titled "The Effect of Game-Supported Mathematics Teaching on the Development of Achievement, Achievement Motivation, Self-Efficacy, and Attitudes of Primary School 6th Grade Students on Fractions."

The test aimed to measure the achievement levels of students in the fractions unit of the 6th-grade mathematics curriculum. In Aksoy's study, the Kuder-Richardson (KR-20) reliability coefficient of the test was calculated at 0.79. In the current study, the reliability coefficients were found to be 0.86 for the pre-test and 0.81 for the post-test. Based on the data obtained, it can be concluded that the achievement test was suitable for this study, and the reliability calculations provide further support.

Since the MAT was used as a pre-existing instrument, its content validity was also examined to assess its appropriateness for the current study. Content validity refers to the extent to which the test questions adequately measure and represent the range of behaviors or skills being assessed. To ensure this, it is crucial to create a specification table that maps the subject matter to the intended learning outcomes for the MAT (Büyüköztürk et al., 2012). In line with this, a specification table was developed after reviewing the content, learning objectives, and the lesson hours dedicated to each objective, based on the input of three lecturers and two elementary mathematics teachers.

2.3.2. Mathematics Attitude Scale (MAS)

In the study, the "Mathematics Attitude Scale," developed by Nazlıçiçek and Erktin (2002), was administered to students in both EG and CG as pre-tests and post-tests to determine whether their attitudes toward mathematics had changed. In the original study conducted by the researchers on 378 secondary school students, the three-factor and 20-item scale had a Cronbach's Alpha reliability coefficient (crα) of 0.841.

In the current study, the reliability coefficients calculated were 0.797 for the pre-test and 0.769 for the post-test, based on the data collected. The scale includes several sub-factors: 6 items related to the "perceived achievement level in mathematics," 5 items related to the "perceived benefits of mathematics," and 9 items related to "interest in mathematics."

2.4. Research Procedures

As part of the research, the students in the EG were taught using teaching materials prepared in Excel, while the students in CG were taught according to the current curriculum. As a result of the research, it was analysed which teaching method was more effective in terms of students' academic achievement and attitudes. What was done during, before and after the application is shown in Table 3:

Table 3.

Procedures

Before	The related literature was reviewed. The data collection tools for the study were selected. The formulas and technical features of the Excel program were explored. Excel worksheets were developed for use in the study. A pilot study was then conducted to test these materials. Based on the data from the pilot study and feedback from experts, any deficiencies in the materials were addressed, making them ready for the actual application. Before the application began, both groups were administered the MAT and MAS.
Teaching process	The students in EG were taught the topic of fractions using computer-aided instructional materials, prepared in the Excel program, within the classroom environment. The students in CG received instruction on fractions in accordance with the standard curriculum in the classroom setting.
After	At the end of the application, MAT and MAS were applied in both groups. The data obtained were analysed.

2.4.1. Teaching materials prepared in Excel

A total of 13 Microsoft Excel worksheets were created in alignment with the objectives of the fractions sub-learning area. Of these, 9 worksheets were designed to reinforce conceptual knowledge, while the remaining 4 focused on exercises and applications related to this knowledge.

The method used by the researcher to design the worksheets is outlined below:

1. The objectives and sample activities from the fractions sub-learning area of the 6th grade mathematics curriculum were reviewed. This included examining the 6th grade mathematics coursebook and workbooks used in the school where the study was conducted.

2. To identify areas where students face difficulties in learning fractions and important information for teaching the subject, interviews were conducted with three experienced primary school mathematics teachers, and relevant literature was reviewed.

3. While reviewing the literature, various instructional design models, existing software, and how these tools addressed the topic of fractions were examined.

4. The opinions of experts and mathematics teachers were sought regarding the prepared materials' alignment with learning outcomes, usability, design of visual elements, color compatibility, and the size of text and figures. Çinar and Ardahan (2003) were referenced for writing formulas.

5. To identify any shortcomings or errors, a pilot test of the material was conducted with another 6th grade class of 28 students from the same school.

6. Based on the data obtained from the pilot test and feedback from three experts and two primary school mathematics teachers, necessary revisions were made to the material, making it ready for use.

The researcher prepared 5 Excel worksheets specifically aimed at tasks such as ordering, comparing, representing fractions on a number line, and estimating the results of operations using strategic approaches.

In the worksheets "Ordering Fractions 1" (Figure 2) and "Ordering Fractions 2" (Figure 3), the goal was to reinforce students' understanding of ordering fractions. The first worksheet focused on fractions with the same numerator but different denominators, while the second addressed fractions with the same denominator but different numerators. These worksheets provided students with the opportunity to practice as much as they needed to solidify their understanding.

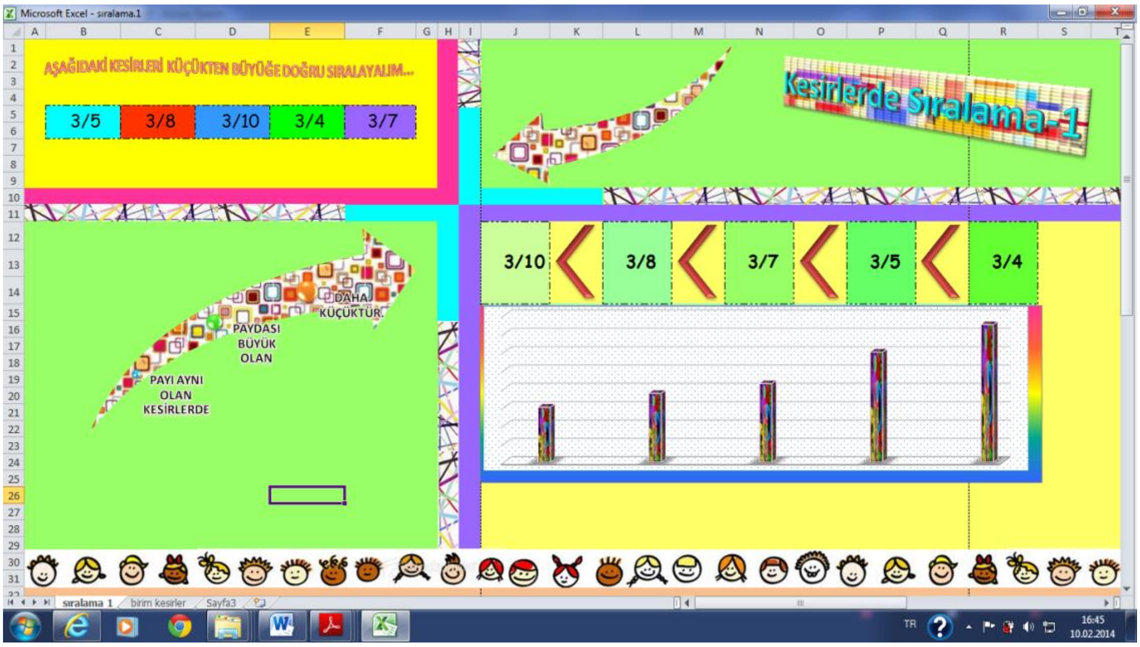

Fig. 2. Ordering Fractions 1

In the upper left corner of the worksheets, there are five empty, colored boxes where students can input fractions with either the same numerator and different denominators, or the same denominator and different numerators. After entering the fractions and pressing the enter key, the fractions are automatically sorted from smallest to largest, with a "<" symbol displayed in the bottom right corner of the worksheet. Simultaneously, a graph below visually represents the relative sizes of the sorted fractions. The name of the activity is displayed in the top right corner of the worksheet, while a reminder of the relevant conceptual knowledge is provided in the bottom left corner.

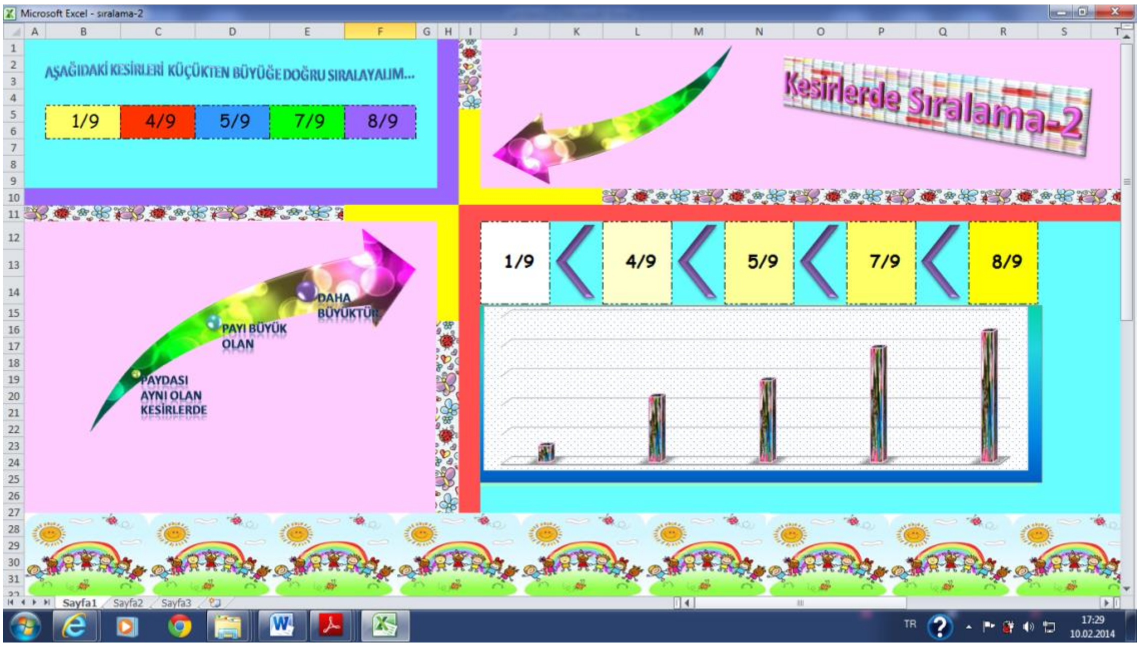

Fig. 3. Ordering Fractions 2

In the "Unit Fractions" worksheet (Figure 4), the aim is to strengthen students' ability to represent simple fractions on a number line. Up to three different fractions can be displayed on the number line simultaneously, though this number can be increased if desired. This feature allows students to visually compare multiple fractions and better understand their placement on the number line.

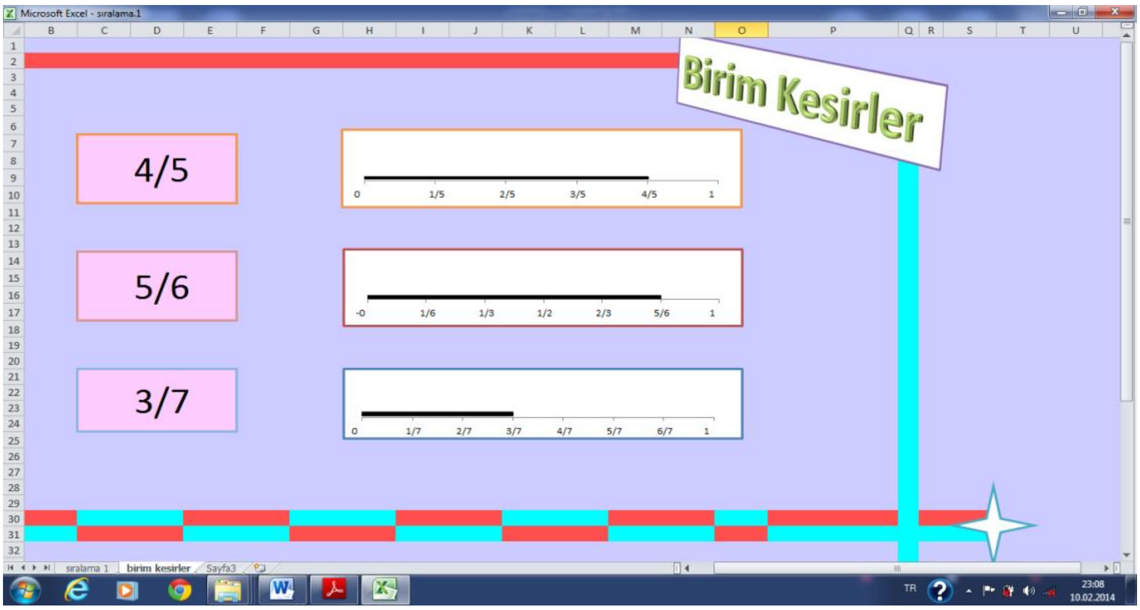

Fig. 4. Unit Fractions

In the "Fractions on the Number Line" worksheet shown in Figure 5, when fractions are entered into the colored boxes in the top left corner of the worksheet and the enter key is pressed, the corresponding fractions appear on the number line in the graph located at the bottom right corner. Each fraction is displayed in the same color as the box where it was written. Additionally, in the lower left corner of the worksheet, the fractions on the number line can be reviewed in ascending order, from smallest to largest.

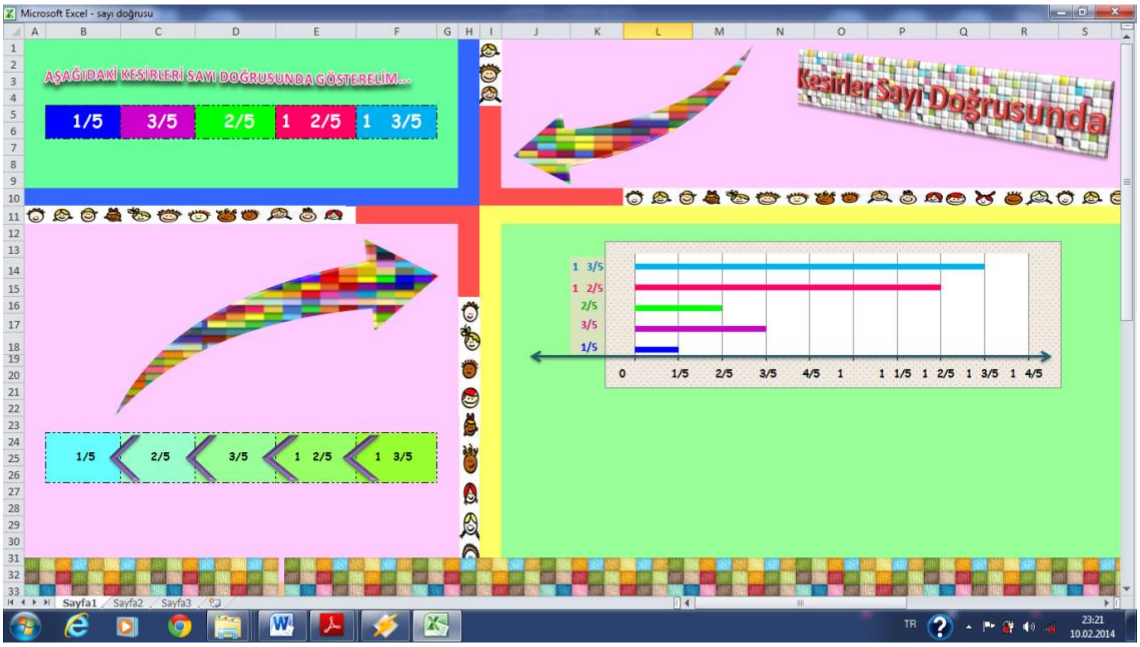

Fig. 5. Fractions on the Number Line

The worksheet titled "Which Fraction is Closer to a Half and Which Fraction is Closer to a Whole" in Figure 6 allows students to verify their predictions using a specific strategy. Although the worksheet employs the logic of displaying fractions on a number line, the number line is designed to only show the points for half and whole values, helping students focus on these benchmarks.

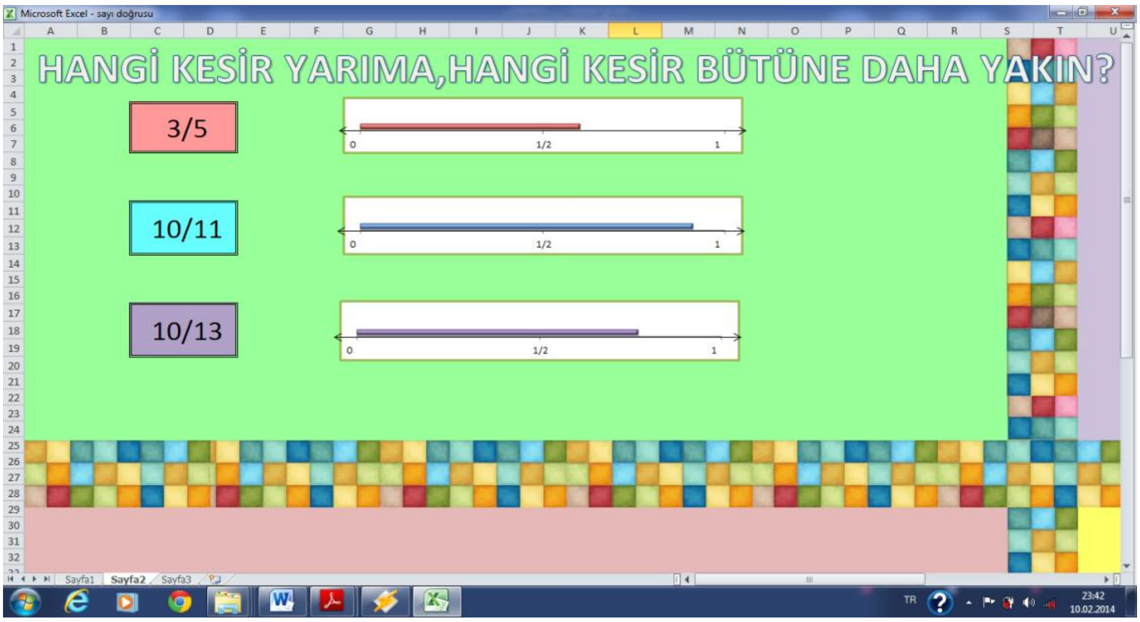

Fig. 6. Which Fraction is Closer to a Half and Which Fraction is Closer to a Whole

Two worksheets were created to reinforce and practice the conceptual understanding of addition and subtraction with fractions. The worksheet titled "Addition Operation in Fractions," shown in Figure 7, was specifically designed to strengthen students' knowledge and skills in performing addition with fractions.

Fig. 7. Addition Operation in Fractions

The worksheet is designed to guide students through the entire sequence of operations involved in adding two fractions. It features a train with three carriages, each representing a step in the process. First, the fractions to be added are written in the first carriage, and the student clicks one of the buttons at the bottom, depending on whether the denominators are equal or unequal. As a result, the second carriage displays the operations needed to match the denominators of the fractions. In the third carriage, the simplified result of the addition is shown.

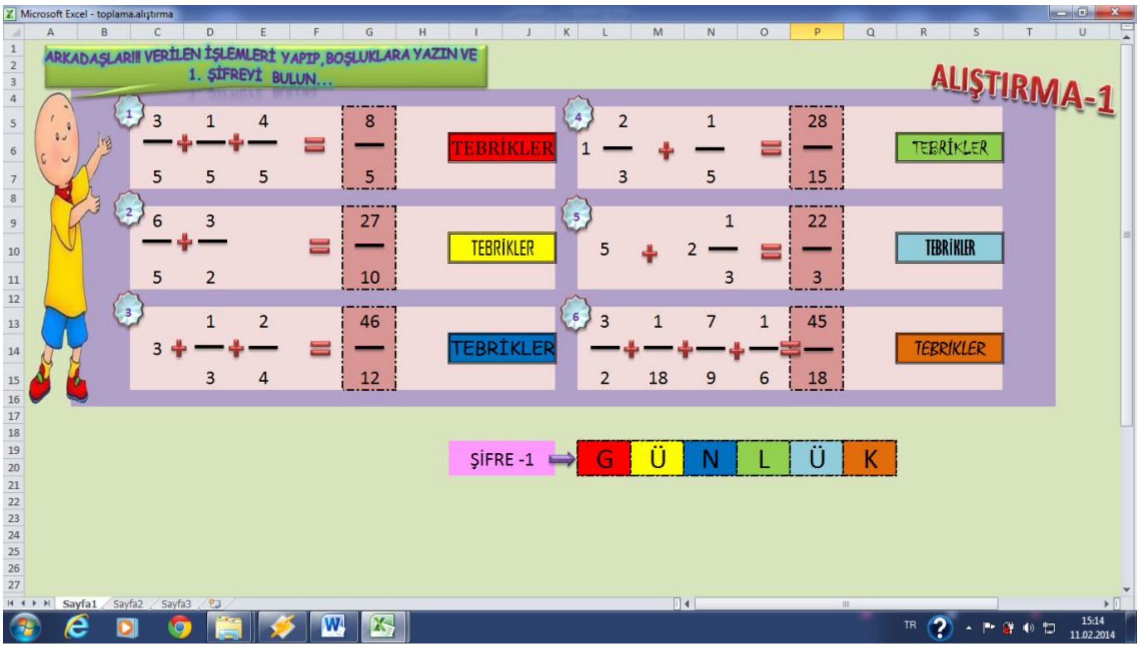

Fig. 8. Exercise 1

Additionally, a reminder is provided at the top of the page, with a warning that the denominator cannot be zero, even if the student attempts to enter 0 in one of the denominators. Furthermore, the worksheet titled "Exercise 1" (Figure 8) has been developed to give students practice with adding fractions.

The worksheet "Exercise 1" contains six questions focused on addition with fractions, along with a password system to ensure continuity. When a student enters the correct answer in the box next to each question, a "Congratulations" message appears, and a letter from the password is revealed. To provide practice with subtraction, multiplication, and division of fractions, similar worksheets have been developed, modeled after the "Exercise 1" addition worksheet. Each of these worksheets has a password, and when all passwords from the worksheets are combined, they form a meaningful phrase for students to reflect on.

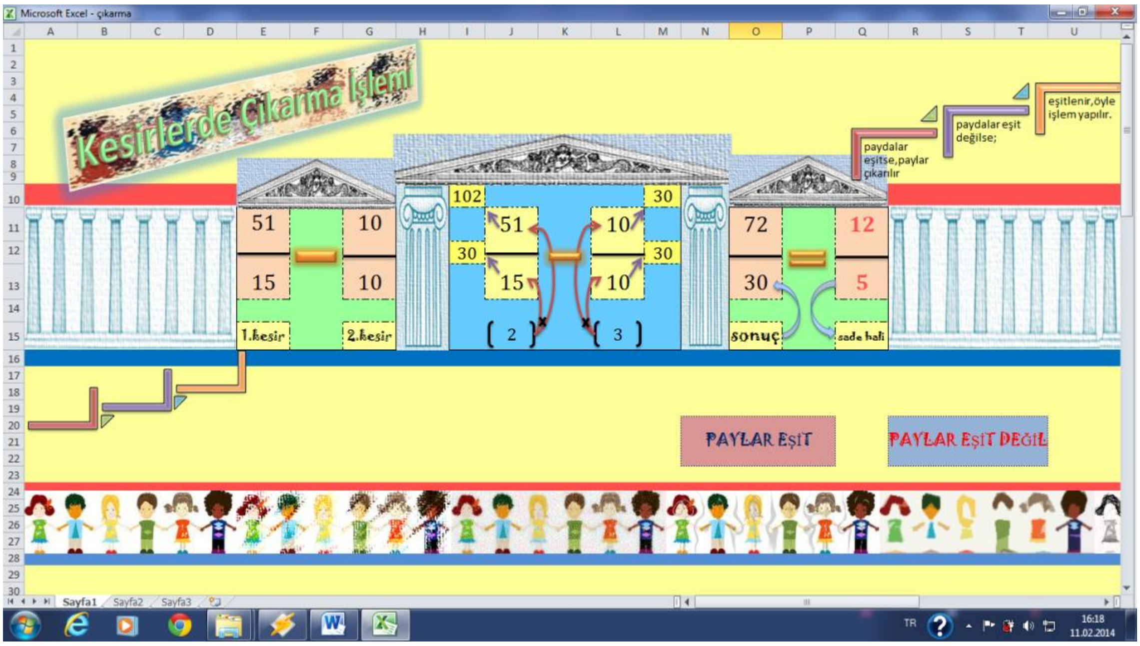

Fig. 9. Subtraction of Fractions

The worksheet designed to help students consolidate their knowledge and skills in subtracting fractions is shown in Figure 9. It follows the same sequence of operations as the worksheet created for adding fractions, ensuring consistency in the learning process.

Fig. 10. Multiplication in Fractions

The worksheets on multiplication and division of fractions are displayed in Figure 10 and Figure 11. In addition to these, two other worksheets have been developed, containing exercises related to multiplication and division. In the multiplication worksheet shown in Figure 9, students are tasked with multiplying two fractions by entering them into the designated areas on the page and pressing the enter key. The worksheet then allows students to analyze the simplified form of the result.

The worksheet for the division of fractions, shown in Figure 11, has been designed in a similar manner, with the steps of the operation displayed in interconnected circles. This layout is intended to highlight each step of the division process, guiding students through the sequence in a visually clear and engaging way.

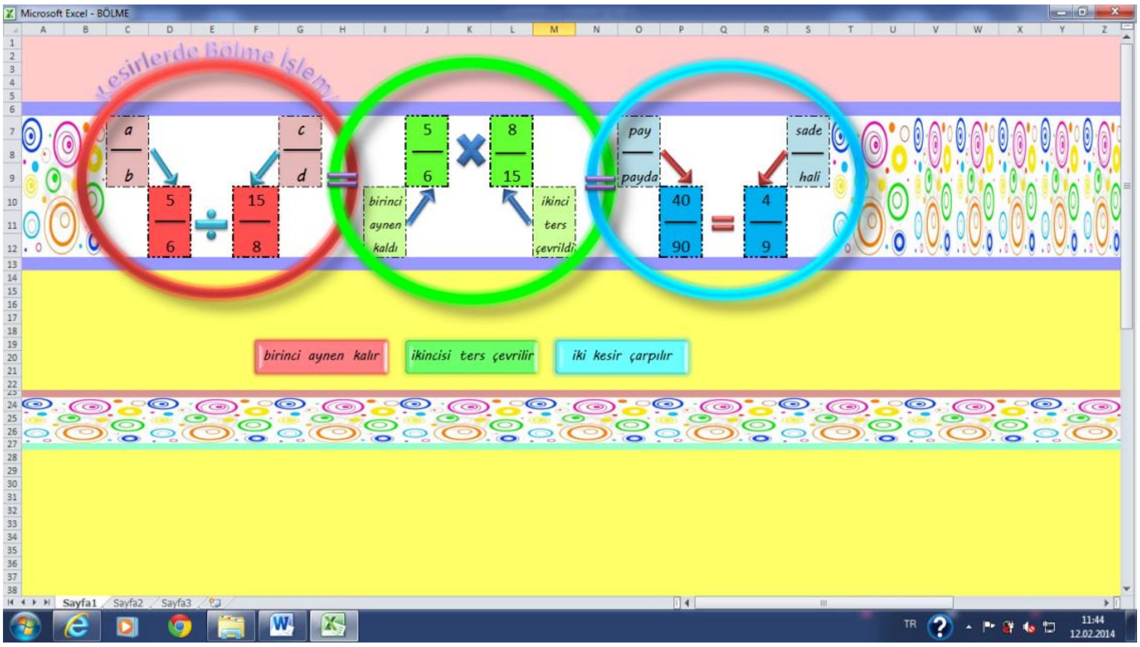

Fig. 11. Division of Fractions

2.4.2. Pilot Scheme

The pilot study was conducted with class 6-B, which had 28 students from the same school. Of these students, 10 were boys and 18 were girls. The students' average GPA was 81.3 in grade 4 and 83.98 in grade 5. Based on the opinions of the mathematics teachers and the students' GPAs, this class was deemed suitable for the pilot study.

In the pilot study, the students were not given pre- and post-tests as in the main study. Instead, over the course of about three weeks, the topic of fractions was taught using Excel worksheets. Information forms were distributed to the students based on the materials used, and at the end of each lesson, semi-structured opinion forms were handed out to gather their feedback on the instructional materials. These opinion forms were prepared by the researcher in collaboration with an expert, and a lecturer with expertise in Turkish language teaching was consulted to ensure the appropriateness of the verbal expressions used.

The data gathered from the pilot study were used to refine the Excel worksheets by making the necessary corrections and improvements. These revisions (improving the visuals in Excel worksheets, making them easier for students to use, increasing the number of examples) were made in line with the feedback from two primary school mathematics teachers and four lecturers, two of whom were from different universities.

2.5. Data Analysis

The data were analyzed using the SPSS software package. Prior to analysis, the data were checked for normal distribution. As a result of the normality analysis, since the data of the control and experimental groups were found to be normally distributed, the dependent samples t-test was used when analysing the same group, while the independent samples t-test was used for comparisons between groups. The significance of the difference between means was interpreted at the 0.05 level.

To assess the reliability of the data collection instruments, KR-20 reliability coefficients were calculated for the MAT, crα were obtained for the MAS. Additional statistical techniques, such as frequency, sample mean, standard deviation, and effect size, were also employed. The results were interpreted based on their statistical significance.

3. Findings

3.1. Findings related to the first sub-problem

"Is there a significant difference between the pre-test scores of EG and CG (mathematics achievement)?"

The results of the t-test are shown in Table 4.

Table 4.

t-Test Results for the MAT Pre-Test Scores of EG and CG

Group	N	$\bar{X}$	S	t	sd	p
EG	31	4.93	3.94	0.218	60	0.828
CG	31	5.16	4.21			

Analyzing Table 4, the mean pre-application MAT score for students in the experimental group (EG) is 4.93, while for students in the control group (CG), it is 5.16, showing a 0.23-point difference in favor of the CG. A t-test was conducted to assess whether the difference between the sample means of EG and CG on the MAT was statistically significant.

The results indicated that the difference was not significant [$t(60) = 0.218$, $p > .05$]. Therefore, it can be concluded that the MAT scores of students in both groups are equivalent. This analysis of pre-test score means suggests no difference in the academic achievement levels between the two groups concerning fractions in mathematics prior to the intervention.

3.2. Findings related to the second sub-problem

"Is there a significant difference between the pre-test scores of EG and CG (attitudes towards mathematics)?"

The results of the t-test are shown in Table 5.

Table 5.

t-Test Results for the MAS Pre-Test Scores of EG and CG

Group	N	$\bar{X}$	S	t	sd	p
EG	31	80.35	6.67	0.169	60	0.867
CG	31	80.67	8.31			

Examining Table 5, the mean pre-test score on the MAS for the experimental group (EG) is 80.35, while for the control group (CG) it is 80.67, showing a 0.32-point difference in favor of the CG. A t-test was conducted to determine whether the difference between the sample means of EG and CG's MAS pre-test scores was statistically significant.

The results indicated that the difference was not significant [$t(60) = 0.169$, $p > .05$]. Therefore, it can be concluded that the MAS scores of both groups are equivalent. The pre-test score means suggest there was no difference in students' attitudes between EG and CG prior to the intervention.

3.3. Findings related to the third sub-problem

"Is there a significant difference between the pre-test and post-test scores of the EG (mathematics achievement)?"

The results of the dependent samples t-test are shown in Table 6.

Table 6.

t-Test Results for EG Pre-Test and Post-Test Scores on the MAT

Group	N	Test	$\bar{X}$	S	t	sd	p
EG	31	Pre-Test	4.93	3.94	10.659	30	0.000
		Post-Test	11.06	5.36			

Examining Table 6, the average score of students in the experimental group (EG), where fractions were taught using the Excel program, increased from 4.93 before the intervention to 11.06 after it, showing a 6.13-point improvement in favor of the post-test. A t-test was conducted to determine whether this difference between the pre- and post-test scores on the MAT was statistically significant. The results confirmed that the difference was indeed significant [$t(30) = 10.659$, $p < .05$]. These findings indicate that the students' academic achievement in fractions significantly improved following the use of teaching materials developed with the Excel program.

3.4. Findings related to the fourth sub-problem

"Is there a significant difference between the pre-test and post-test scores of the EG (attitudes towards mathematics)?"

The results of the t-test are shown in Table 7.

Table 7.

t-Test Results for EG Pre-Test and Post-Test Scores on the MAS

Group	N	Test	$\bar{X}$	S	t	sd	p
EG	31	Pre-Test	80.35	6.67	8.445	30	0.000
		Post-Test	88.96	6.48			

In Table 7, the mean scores of students in the experimental group (EG), who were taught fractions using Excel, increased from 80.35 before the intervention to 88.96 afterward, reflecting an 8.61-point rise in the sample mean, favoring the post-test results. A t-test was conducted to assess whether the difference in the sample means of students' MAS scores before and after the intervention in EG was significant. The results indicated a statistically significant difference [$t(30) = 8.445$, $p < .05$].

This significant change suggests that the use of teaching materials developed with Excel contributed to a notable improvement in the students' attitudes toward the mathematics course.

3.5. Findings related to the fifth sub-problem

"Is there a significant difference between the pre-test and post-test scores of the CG (mathematics achievement)?"

The results of the t-test are shown in Table 8.

Table 8.

t-Test Results for CG Pre-Test and Post-Test Scores on the MAT

Group	N	Test	$\bar{X}$	S	t	sd	p
CG	31	Pre-Test	5.16	4.21	8.609	30	0.000
		Post-Test	7.96	5.06			

In Table 8, the mean scores of the control group (CG), who were taught fractions using curriculum-prescribed activities, increased from 5.16 before the intervention to 7.96 afterward, showing a 2.8-point improvement in the sample mean, favoring the post-test results. A t-test was conducted to determine if the difference between the sample means of the CG students' MAT scores was statistically significant. The results confirmed this difference as significant [$t(30) = 8.609$, $p < .05$].

Based on this result, there was a notable improvement in the academic achievement of CG students in fractions before and after the intervention. This suggests that the curriculum-based teaching activities had a positive impact on the students' academic performance.

When comparing Tables 6 and 8, both the CG, which followed the standard teaching method, and the experimental group (EG), which used Excel-based instruction, showed increased academic achievement after the intervention. Despite the differing instructional approaches, learning occurred in both groups. The EG, which used Excel-prepared materials, demonstrated a 6.13-point improvement, while the CG, using curriculum-prescribed activities, showed a 2.8-point improvement. These results suggest that the EG experienced greater academic growth.

3.6. Findings related to the sixth sub-problem

"Is there a significant difference between the pre-test and post-test scores of the CG (attitudes towards mathematics)?"

The results of the t-test are shown in Table 9.

Table 9.

t-Test Results for CG Pre-Test and Post-Test Scores on the MAS

Group	N	Test	$\bar{X}$	S	t	sd	p
CG	31	Pre-Test	80.67	8.31	5.318	30	0.000
		Post-Test	87.51	8.37			

In Table 9, the mean scores of control group (CG) students, who were taught fractions using curriculum-prescribed activities, increased from 80.67 before the intervention to 87.51 afterward, reflecting a 6.84-point improvement in the sample mean, favoring the post-test results. A t-test was conducted to assess whether the difference in sample means of the CG students' MAS scores was statistically significant. The results confirmed the significance of this difference [$t(30) = 5.318$, $p < .05$].

These findings indicate a positive change in the attitudes of CG students toward the mathematics course before and after the intervention, suggesting that the curriculum-based teaching activities had a beneficial effect on their attitudes.

3.7. Findings related to the seventh sub-problem

"Is there a significant difference between the post-test scores of EG and CG (mathematics achievement)?"

The results of the t-test are shown in Table 10.

Table 10.

t-Test Results for the MAT Post-Test Scores of EG and CG

Group	N	$\bar{X}$	S	t	sd	p	η^2
EG	31	11.06	5.36	2.337	60	0.023	0.083
CG	31	7.96	5.06				

Analysis of Table 10 reveals that the mean MAT score of students in the experimental group (EG) after the intervention was 11.06, compared to 7.96 for the control group (CG), showing a 3.1-point difference favoring EG. A t-test was conducted to determine whether this difference in post-test MAT scores between the two groups was statistically significant. The results confirmed a significant difference between the groups' sample means [$t(60) = 2.337$, $p < .05$].

These findings indicate that the academic achievement levels of EG and CG students in fractions, which were initially equal, shifted in favor of the EG after the intervention. This suggests that the teaching method used in EG, which incorporated Excel, was significantly more effective than the traditional curriculum-prescribed methods used in CG. In other words, Excel-based instruction proved to be more effective in improving students' mathematics performance.

Furthermore, the analysis revealed that the independent variable (Excel-based instruction) explained 8% of the variance in the dependent variable (academic achievement), with $\eta^2 = 0.083$. This suggests that computer-assisted instruction accounted for 8% of the variance in academic achievement scores, and based on this effect size, the use of Excel has a "moderate" effect on students' academic achievement (Büyüköztürk, 2010).

3.8. Findings related to the eighth sub-problem

“Is there a significant difference between the post-test scores of EG and CG (attitudes towards mathematics)?” The results of the t-test are shown in Table 11.

Table 11.

t-Test Results for the MAS Post-Test Scores of EG and CG

Group	N	$\bar{X}$	S	t	sd	p	η^2
EG	31	88.96	6.48	0.763	60	0.448	0.01
CG	31	87.51	8.37				

A t-test was conducted to determine whether the difference between the sample means of the MAS scores for the experimental group (EG) and the control group (CG) was significant. The results indicated that the difference between the groups was not statistically significant [$t(60) = 0.763$, $p > .05$]. This suggests that the MAS scores of EG and CG students were similar, and there was no notable difference in their attitudes toward the mathematics course after the intervention.

When examining Tables 7 and 9, the data shows an improvement in students' attitudes in both groups after the intervention—whether using the standard curriculum-based teaching for CG or Excel-based instruction for EG. The post-test mean difference for EG, which used Excel-prepared materials, was 8.61, while CG, following program-prescribed activities, showed a difference of 6.84. Additionally, the calculated effect size ($\eta^2 = 0.01$) indicates that 1% of the variance in students' attitude scores was explained by computer-assisted instruction. Based on this small effect size, it can be concluded that using Excel had a minimal impact on improving students' attitudes.

4. Discussion and Conclusion

This study, aimed at investigating the effect of teaching materials prepared in Excel on students' academic achievement and attitudes, was carried out in a public secondary school for three weeks on a total of 62 students in classes 6-A and 6-C, whose class sizes were determined to be equal and equivalent to each other. Considering the results related to the sub-problems formed on the basis of the general problem, the following conclusions were reached:

4.1. The Effect of Excel Use on Academic Achievement

The mean of test scores of EG who learned with Excel and the students in CG who were given the teaching method prescribed by the curriculum, and their changes, are shown in Figure 12.

It was observed that there was a difference in favour of the post-test between the mean scores of EG, in which the programme Excel was used in the application of computer-assisted instruction, in the achievement test on fractions before the application and the mean scores after the application. This result indicates that the using Excel had a positive effect on the students' academic achievement.

On the other hand, it was observed that there was a difference in favour of the post-test between the mean scores of CG, in which mathematics was taught according to the teaching method prescribed by the curriculum, and the mean scores of EG. This result shows that the use of the teaching activities prescribed by the programme, as in using Excel, increases student achievement.

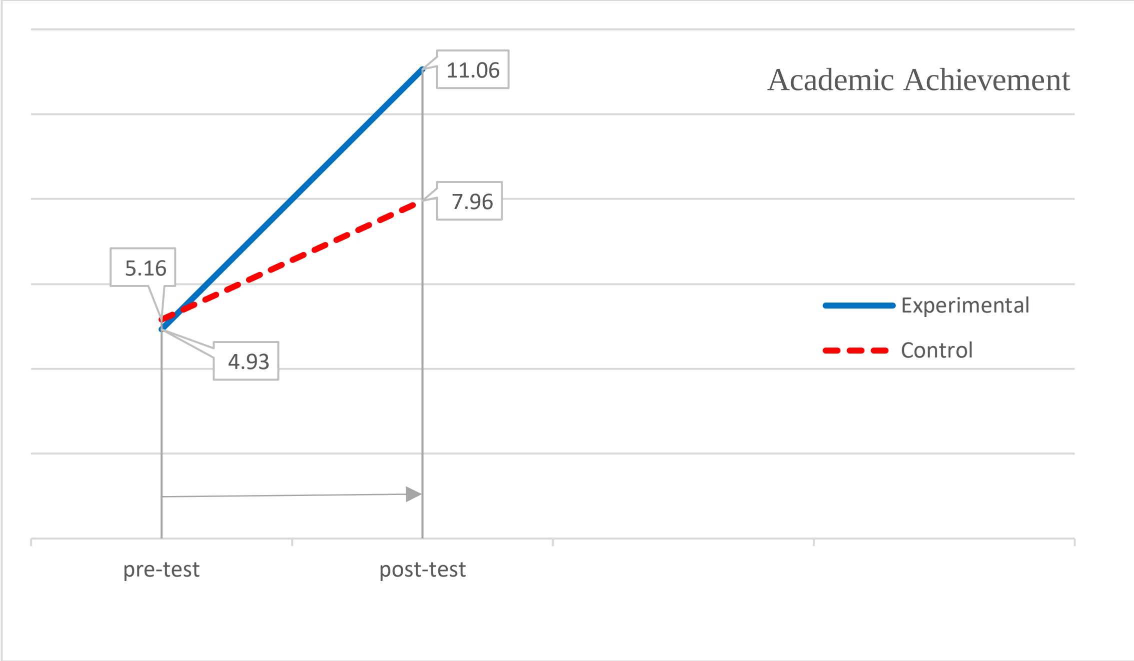

Fig. 12. Mean MAT scores of EG and CG

The results show that the academic performance of both CG, in which the current teaching method was used, and EG, in which the Excel was used, increased after the application. It is obvious that learning takes place even though the applications are different. However, although the academic achievement of the students in both groups increased, it is obvious that the students in EG showed more improvement (Figure 12). While the average of the post-test scores of CG students remained at 7.96, the average of the scores of EG students increased to 11.06. This shows that the using Excel applied to the students in EG is a more effective teaching method in improving student achievement than the current teaching method. The finding of a difference in favour of EG in the analysis of the mean post-test scores of EG and CG also supports this finding.

These findings at the end of the research support the results of previous studies that investigated the positive effect of computer-assisted instruction on student achievement in mathematics education (Budak, 2000; Christensen & Stephens, 2003; Neurath & Stephens, 2006; Nwabueze, 2006; Birgin et al, 2008; Helvacı, 2010; Bayturan, 2011; Tayan, 2011; Aksoy et al., 2012; Başaran Şimşek, 2012; Babapour Golezani, 2012; Yahşi Sarı, 2012).

4.2. The Effect of Excel Use on Attitude

The mean of test scores on the MAS of the students in EG learning with Excel and the students in CG using the curriculum-prescribed teaching method, and their changes, are shown in Figure 13.

It was found that there was a difference in favour of the post-test between the mean scores of EG, in which the programme Excel was used in the application of computer-assisted instruction, and the mean scores of the post-test. This result indicates that the using Excel caused an increase in the students' attitudes.

On the other hand, it was observed that there was a difference in favour of the post-test between the mean scores of CG, in which mathematics was taught according to the teaching method prescribed by the curriculum, and the mean scores of EG before and after the application. This result shows that using the teaching activities prescribed by the curriculum, as in using Excel, improves students' attitudes.

The results show that both CG, in which the current teaching method was used, and EG, in which the Excel was used, improved their attitudes after the application. Although the applications are different, the improvement in students' attitudes is clear.

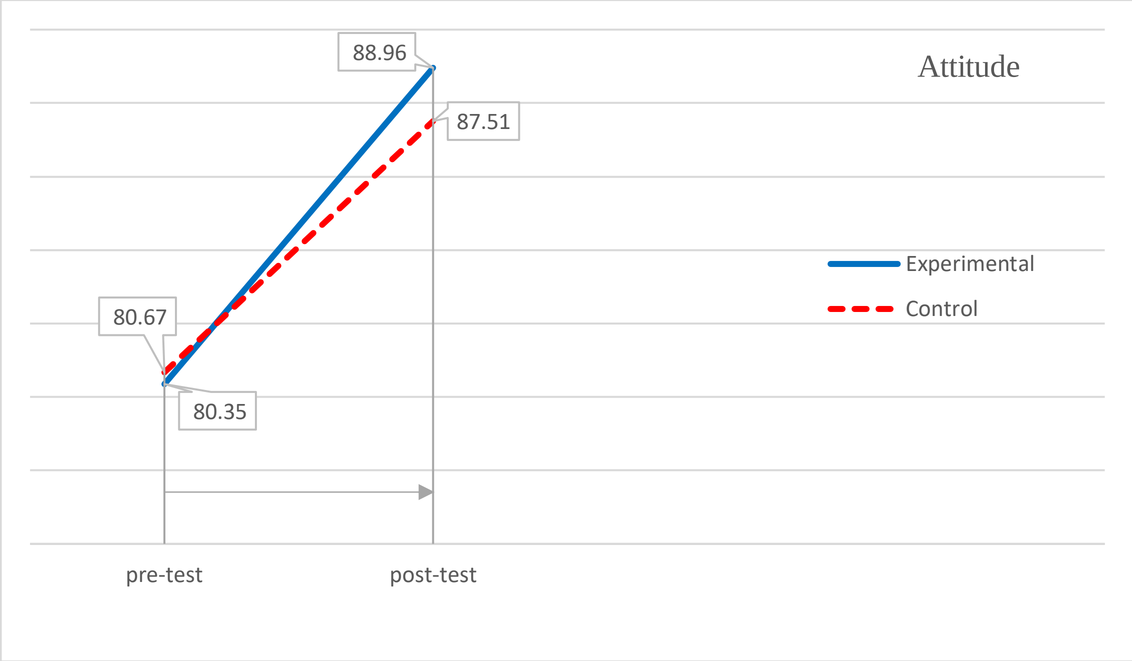

Fig. 13. Mean MAS scores of EG and CG

In the analysis, no difference was found between the mean scores of EG and CG students on the attitude scale after the application. Although, according to the data obtained, there was a greater improvement in the attitudes of the students in EG who had been taught with the Excel compared to the attitudes of the students in CG who had been taught with the current teaching method (Figure 13), the fact that no difference was found shows that the rate of effect of the two methods on attitudes is not different. It can be said that these results are due to the individual differences of the students, the subject being taught and the physical facilities. On the other hand, it is also stated in the literature that it may be due to the difficulty of changing students' attitudes in the short period of time in which the experimental study was conducted (Berika Kansoy & Sert Çıbık, 2022).

These findings support the results of some previous studies investigating the effect of computer-assisted instruction on attitudes towards mathematics (Ganguli, 1990; Buran, 2005; Tutak, 2008; Çankaya & Karamete, 2008; Bayturan, 2011).

4.3. Suggestions

In the light of the results of the study, the following suggestions have been made, which are considered useful:

Since this study concluded that the use of teaching materials prepared in Excel programme in the teaching of 6th grade subject 'Fractions' increased students' achievement and attitude, research can be conducted to investigate the effectiveness of this method in other subjects of mathematics course and other levels of primary and secondary education. Similarly, studies can be carried out to compare the Excel programme with other software used in computer-assisted teaching from various points of view.

Studies can be carried out to investigate the effect of the computer-assisted teaching method using the Excel programme on factors other than attitudes and academic achievement. The study looked quantitatively at the effect of computer-assisted instruction using an Excel programme on academic achievement and attitudes. In a similar study, qualitative data can be obtained using methods such as interviews and observations.

The teaching materials used in the application were prepared by the researcher for use by the students using the relevant formulas in the Excel programme. Studies can be carried out in which the writing of the worksheet formulas to be used in the application to the Excel programme is done with the students and then the application is carried out.

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