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The Effect of the Use of Educational Digital Comics in Science Teaching on Academic Achievement

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ABSTRACT

This study aims to determine the effect of the use of educational digital comics designed for the topics of "Energy Conversions" and "Food Chain and Energy Flow" within the "Energy Conversions and Environmental Science" unit of the 8th-grade science curriculum on students' academic achievement. The research employed a quantitative methodology and utilized a quasi-experimental design with random sampling, involving 63 eighth-grade students. SPSS 22.0 analysis program was used to analyze quantitative data collected during the study. As a result of the analysis, a significant difference was found between the academic achievement mean scores of the experimental group students, in which the educational comics were used, and the control group students. Based on our finding that using educational comics has a positive effect on students' success, it is thought that the use of these materials, which can make learning more fun and permanent, should be expanded.

Keywords: Educational comics, science education, academic achievement

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Introduction

Technology, which is included in educational and instructional studies, provides significant support to both students and teachers in terms of materials. The utilization of materials in education not only saves time but also enhances academic achievement by facilitating the acquisition of desired skills and ensuring that the knowledge gained becomes more permanent (Cohen, 1992; Çilenti, 1988; Gürbüz, 2006; Karataş & Yapıcı, 2006; Şimşek, 2002; Yanpar-Şahin & Yıldırım, 1999; Yaşar, 2006; Yıldırım, 2016). One of the technological materials used in education is educational digital comics.

In the 21st century, comics have been integrated into the science education process (Aisyah et al., 2017). Although comics which have existed for centuries and were seen as entertainment tools covered topics such as political criticism and social issues, they have now emerged as valuable educational tools (McCloud, 2001; Widyastuti et al., 2017). The interest shown by children in comics is great (Sheu & Chu, 2017). The short structure of comics is regarded as a beneficial feature for students who cannot spend long periods of time reading (Negrete, 2013). Comics utilize a visual language and make learning interesting (Tekin & İlhan, 2021). Educators use plots and funny visuals appropriate to the curriculum in the educational comic book stories they design to attract students' attention (Bitz & Emejulu, 2016). Given that students generally prefer books with visual elements (Lin & Lin, 2016), comics serve as an enjoyable and stimulating learning environment for students across all educational levels (Maryani & Amalia, 2018; Toh, 2009). Therefore, it can be inferred that learning can be more effective as students' reading a book they like will contribute positively to their motivation to learn. By incorporating comics into the curriculum, students' curiosity will remain high, and they will encourage themselves to learn and understand the lesson as intrinsically motivated individuals (Kim, et al., 2017).

Turkey Century 2024 Maarif Model Science Course Curriculum adopts a holistic educational approach that centers on the student. The program aims to raise students as individuals equipped with the comprehensive skills necessary for the modern era, actively participate in group work in cooperation during learning processes, have self-regulation skills, are researching, questioning, critical thinkers, environmentally sensitive, and display scientific attitudes and behaviors. Additionaly, raising individuals who are aware of digital transformation and can adapt to changing technology is shown among the goals of science education (MONE, 2024). The incorporation of digital comics serves as a material that can help achieve these educational goals. Digital comics, as technological tools integrated into educational activities, can significantly support both students and teachers in achieving targeted learning outcomes.

When reviewing the literature, it is evident that numerous studies have examined the effects of using comics in education and instruction. One study found that incorporating comics into educational settings significantly enhanced students' motivation, vocabulary, and writing skills (Themelis & Sime, 2020). The visual elements presents in comics have a positive effect on permanence and remembering as they foster reconstruction in the mind. Foreign language teachers frequently employ this method to make reading more fun and understandable (Liu, 2004). A similar investigation focused on teaching Japanese, where students demonstrated notable improvements in language acquisition through the use of comics and expressed that they found comics interesting (Lai et al., 2002). In another study, it indicated that comics possess a more flexible structure compared to other educational materials, and allowing for a stronger connection with the reader (Guadamillas Gómez, 2014).

Özdemir (2010) revealed that educational comics enhance success in teaching some abstract concepts. Similarly, comics have been recognized as a powerful complementary teaching tool that helps to concretizes abstract concepts (Akcanca, 2020). Toh (2009) stated that students with visual-kinaesthetic intelligence are unsuccessful in today's education system. It was determined that these students generally enjoy reading comics, and the incorporation of comics in education could provide equal opportunities for students. In a study conducted on preschool children concluded that literacy was encouraged with comic books (Muniran & Yusof, 2008). In some studies based on student opinions, it has been stated that educational comics have been reported as interesting and motivating for learning (Bhatia, 2006; Song et al., 2008). Additionaly, Ranker (2008) revealed that comic books play a significant role in developing essential life skills, such as speaking, writing, thinking, and imagination. The effectiveness of comic books in fostering reading habits among children is attributed to their colorful, engaging narratives and visual elements (Cary, 2004). Haugaard (1973) also stated that children's interest in lessons would increase with comics.

Comics created using traditional drawing methods take a long time and require special talent. Digital comics are easier to their traditional counterparts (Balaban, 2007). With Web 2.0 tools, illustrations can be produced quickly, offering limitless coloring options and facilitating easier sharing. A review of the literature reveals that various studies conducted in recent years have demonstrated the positive effects of utilizing Web 2.0 tools in science education (Akbaba, 2019; Arslan & Akçay, 2022; Bilen et al., 2019; Bilgican Yılmaz et al., 2021; Gürleroğlu, 2019; Korucu, 2020;. Uysal, 2020; Yıldırım, 2020).

It is known that visual materials play a crucial role in science education by helping to concretize abstract concepts, thereby effectively enhancing student success. From this perspective, it is obvious that comics should be integrated into in science lessons. Consequently, the current study aims to provide resources for comic-supported learning by developing materials in the field of science and contributing to the literature by measuring the effect of comics on student achievement. At the same time, improving the quality of online science education and revealing the role of educational digital comics as a material that supports online science education are among the expected research outputs. It is also expected to introduce Web 2.0 tools used by educators in times such as the pandemic, where we are familiar with distance education, to eliminate concerns about this issue and to guide science educators in making recommendations about the tools. Using digital tools can also help encourage positive student engagement in the classroom and provide flexible and accessible learning options that are exciting for students. Based on all these points, the aim of the current study is to design educational digital comics on the topics of "Energy Conversion" and "Food Chain and Energy Flow" given within the unit of "Energy Conversions and Environmental Science", which is the 6^{th} unit of the 8^{th} grade science curriculum (MONE, 2018) and to investigate whether the use of digital comics in education has an effect on the academic achievement of students.

Method

Research model

This study was conducted using a quantitative research methodology and a pre-test-post-test quasi-experimental design with a control group (Campbell & Stanley, 1963). Since the quasi-experimental design method is appropriate for studies in which different treatments administered to groups are compared and then the effects of the elements included in the study are examined (Büyüköztürk, 2013), this method was used in the current study. The main stages of the study are illustrated in Figure 1.

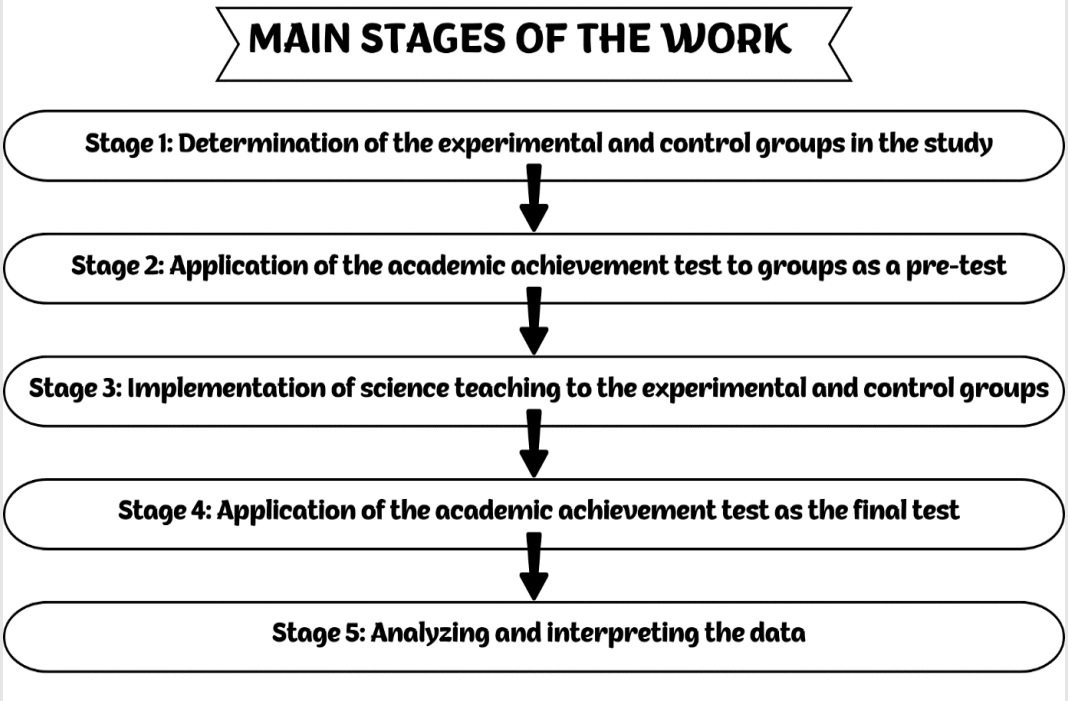

Figure 1. Stages of the research process based on the quasi-experimental design

Group-universe/sample

The study was conducted with 63 eighth-grade students attending a public school in the city of Kırsehir during the 2022–2023 academic year. To enhance the practicality and efficiency of the research, experimental (N=32) and control (N=31) groups were created using the easily accessible sampling method, which is a type of the purposeful sampling types. The experimental group consisted of 14 female and 18 male students, while the control group included 15 female and 16 male students.

Data collection tool

Since the literature review indicated that no existing data collection tool comprehensively addressed the study's subject, the researcher developed an academic achievement test. Initially, a question pool consisting of 45 multiple-choice questions each with four options was created. Subsequently, the researcher sought feedback from nine experts (5 Biology, 3 Science, 1 Turkish) and as a result, the test was reduced to 27 questions. Sample items from the academic achievement test are presented in Figure 2.

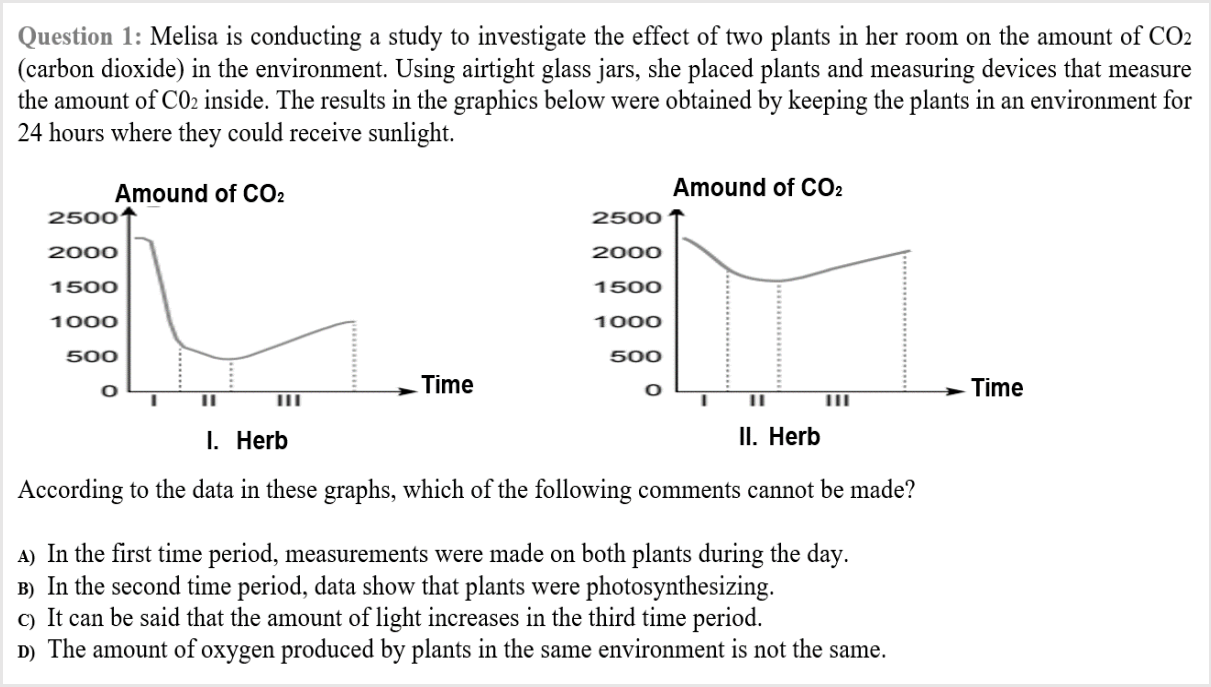

Figure 2. Sample questions from the academic achievement test

Before starting the data collection process, reliability analyses for the "Photosynthesis and Food Chain Academic Achievement Test" were conducted based on self-reports from 150 (9^{th} grade) students who were not part of the study group. In the validity analysis of the test items, a specification table for content validity was created with the assistance of three experts. Item discrimination (0.663), and item difficulty indexes (0.496) were calculated and tabulated. Consequently, three items were not included in the academic achievement test because they were found to not meet the criteria taken as basis in the studies conducted in previous years (Hasançebi et al., 2020; Tan, 2010). For the reliability analysis concerning the internal consistency of the test items, the Kuder-Richardson-21 reliability coefficient was calculated to be 0.761. It was accepted that this result met the reliability criterion that should be found in the academic achievement test (Pallant, 2020). In this connection, it can be said that the academic achievement test is reliable, has medium difficulty, and comprises high-quality items. As a result of the validity and reliability studies, the final version of the academic achievement test was given to be consisted of 24 items. The highest score to be taken from the academic achievement test is 24, and the lowest score is 0.

The normality analysis of the prepared academic achievement test was also performed. As a result of the analysis, it was seen that the Kolmogorov-Smirnov value was not significant ($p>0.05$) and the Skewness-Kurtosis coefficients were found to be between -1 and +1 (Table 1). Based on these results, it was concluded that the academic achievement test data had a normal distribution (Kline, 2011; Tabachnick & Fidell, 2015).

Table 1. The normality analysis results of the academic achievement test

	Statistics	df	Skewness	Kurtosis	p
Sample	.072	150	.204	-.342	.067

The 1st, 4th, 9th, 10th, 12th, 17th, 18th, and 21st items on the academic achievement test are designed to measure the accomplishment of the objective "Gives examples of producers, consumers, and decomposers in the food chain". The 5th, 6th, 7th, 14th, and 20th items are prepared to measure the accomplishment of the objective "Recognizes the importance of photosynthesis in food production in plants". The 2nd, 3rd, 8th, 11th, 13th, 15th, 16th, 19th, 22nd, 23rd, and 24th items are prepared to measure the accomplishment of the objective "Makes inferences about the factors affecting the rate of photosynthesis".

Data collection

Each step of the implementation process for the experimental study was carried out in a total of 20 class hours. The implementation period was shaped based on the data in the annual plan made based on the science curriculum. In the study, students who were taught science using the methods in the science curriculum were determined as the control group, and students who were taught science using the educational comic materials were determined as the experimental group.

Implementation process

The implementation process of the research was completed in 20 class hours. The implementation period and process were structured according to the science curriculum. In this study, students who were taught science using comics were designated as the experimental group, while those who received traditional science instruction were classified as the control group.

Experimental group

A summary of the implementation process utilized in the experimental group of the study is presented in Table 2.

Table 2. Research implementation process flow

Course Hours	Implementation Process
1	Administering of the academic achievement test as a pre-test
1	Filling in the parent and student consent forms
1	Introducing the educational comic material application to students
16	Teaching process using the educational comic material
1	Administering the academic achievement test as a post-test
Total 20 hours	

**Each lesson hour consists of 40 minutes.*

Since there was no comic book to be presented to the experimental group in class, it was created by the researcher in three stages (Şahan & Atlı, 2024).

Scenario stage

In the first stage, a scenario was designed for the 8th Grade Energy Transformations and Environmental Science Unit, specifically focusing on the Food Chain and Energy Flow. A draft text was subsequently created. During the text development stage, the breaking points of the scenario, common language with the reader and common living areas were applied and a connection was established between them. Care was taken to ensure that the scenario comprehensively covered the unit's content and maintained scientific accuracy.

Drawing stage

At this stage, the objective is to align the scenario with the drawing. To achieve this, Storyboard That and Canva tools have been selected as the most suitable Web 2.0 tools, offering a variety of background and character options.

Panel stage

The events narrated in the comics consist of consecutive frames. The arrangement of these frames on the screen in printed works or digital platforms is referred to as a panel, while the transitions between frames are known as a sequence (Alpin, 2002). At this stage, both sequences and panels were developed. Since the comics will be displayed on a smart board to present relevant material prepared for the science course to students, they were designed in a size of 1920 x 1080 mm.

In teaching with the educational comics, which is the most important part of the implementation process, the comics, which were converted into PDF format suitable for the smart board (Figure 3), were voiced by volunteer students, and the interpretation of the flow of the events in the story was made through brainstorming in the class.

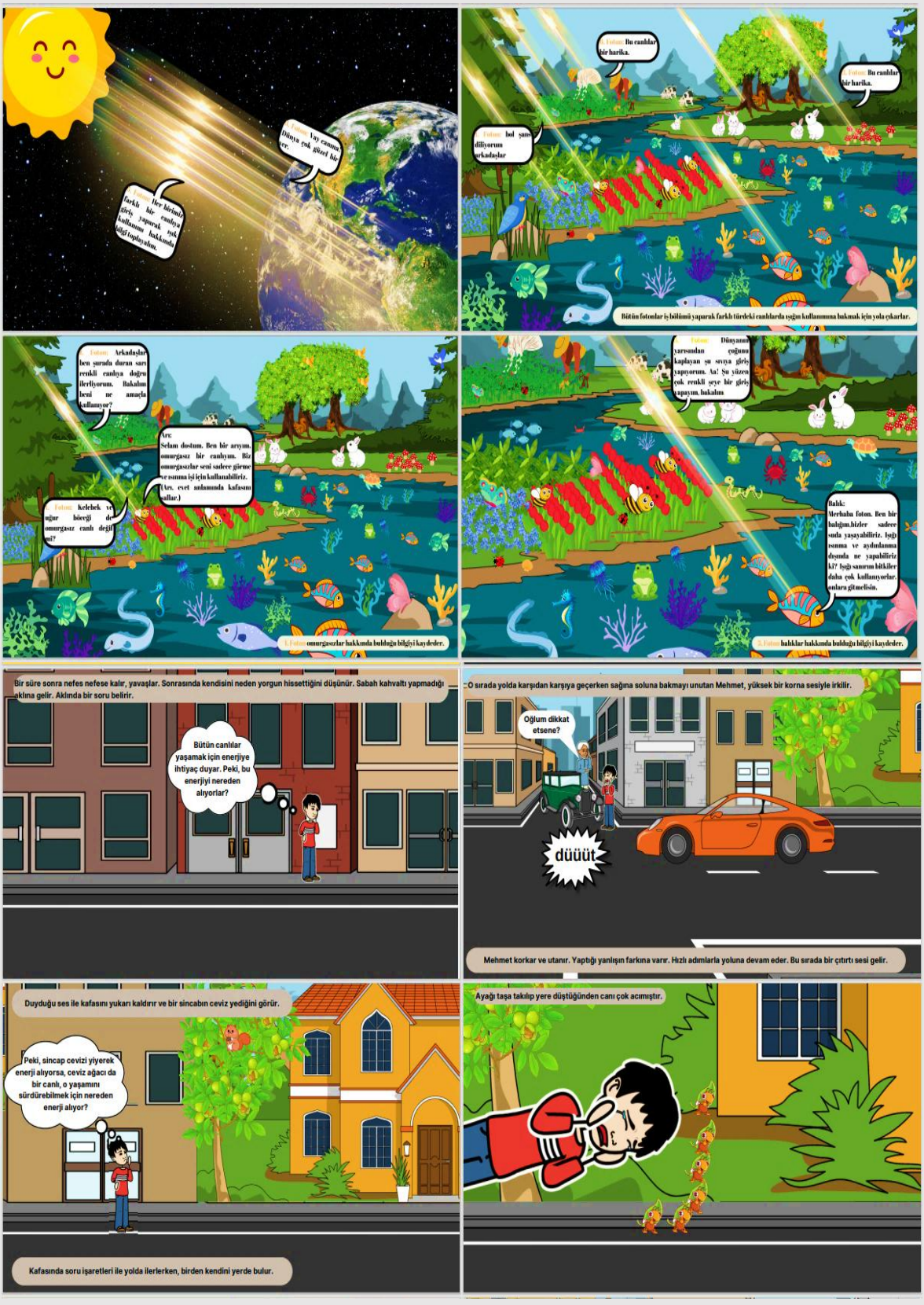

Figure 3. Sample image of the comic book designed in the study

Control group

In the control group, the initial stage of the implementation process involved administering an academic achievement test as a pre-test to assess whether the students' readiness levels were comparable. Subsequently, the course was taught in accordance with the Energy Transformations and Environmental Science Unit achievements in the current curriculum based on the textbook. The students were given the activities in the book and the subject explanations were carried out. At the end of the process, the academic achievement test was administered as a post-test.

Data analyses

The data collected with the academic achievement test were analyzed by using the SPSS 2.0 statistics program. During the analysis, students' correct answers were coded as 1 point, and incorrect answers and unanswered questions were coded as 0 points in the program. Normality analyses of the test results for both the experimental and control groups were conducted using the Shapiro-Wilk test. As a result of this test, independent sample t-test analysis was performed for data with normal distribution and Mann Whitney-U test was performed for groups with non-normal distribution.

Ethics committee approval process

The ethics application for the study was made on 21/10/2022 and the research was carried out with the approval of Nevsehir Haci Bektas Veli University Ethics Commission dated 26/12/2022 and numbered 2022.13.429.

Results

The normality test for the groups to which the academic achievement test was administered was conducted using the Shapiro-Wilk test, and the results are presented in Table 3.

Table 3. Shapiro-Wilk test results of the academic achievement pre-test scores of the experimental and control group students

Groups		Statistics	N	p		Statistics	Standard Deviation
Academic success pre-test	Control Group	.969	31	.492	Skewness	-.241	.421
					Kurtosis	.106	.821
	Experimental Group	.960	31	.298	Skewness	-.170	.421
					Kurtosis	-.311	.821

Since the Shapiro-Wilk coefficient was found to be $p>0.05$, the data were considered to be normally distributed. Furthermore, the Skewness and Kurtosis values were found to be between -1 and +1, which showed that the data exhibited a normal distribution ($Skewness_{Control}$ = -0.241, $Kurtosis_{Control}$ = 0.106, $Skewness_{Experimental}$ = -0.170, $Kurtosis_{Experimental}$ = -0.311).

An independent samples t-test was conducted to determine whether there were any differences in the prior knowledge levels of the students in the groups on the subject, and the results are given in Table 4.

Table 4. Results of the independent samples t-test comparing the pre-test scores of of students in the experimental and control groups

Group	N	$\bar{X}$	SS	sd	t	p
Control Group	31	7.45	2.204	60	.755	.816
Experimental Group	31	7.03	2.236			

The t-test indicated that there was no difference between the experimental and control groups in terms of readiness levels and that there was no prior knowledge level variable in the experimental study to be conducted ($t_{60} = 0.755$, $p>0.05$) (Table 4).

A Shapiro-Wilk test was conducted to determine whether the students' scores from the academic achievement test administered as a post-test exhibited a normal distribution (Table 5).

Table 5. Normality analysis results regarding the academic achievement post-test scores of the control and experimental group students

Groups		Statistics	N	p		Statistics	Standard Deviation
Academic achievement post-test	Control Group	.862	31	.001	Skewness	1.283	.421
					Kurtosis	1.058	.821
	Experimental Group	.955	31	.200	Skewness	-.354	.421
					Kurtosis	-.535	.821

The nonparametric independent samples (post-control and post-experimental), which were determined not to exhibit a normal distribution, were analyzed with the Mann Whitney-U test and the results are presented in Table 6.

Table 6. Results of the Mann-Whitney U analysis comparing the academic achievement post-test scores of students in the control and experimental groups

Groups		N	Mean Rank	Sum of Ranks	U	p
Control Group	Pre-test	31	23.97	743	247.00	.001(*)
Experimental Group	Post-test	31	39.03	1210		

A significant difference was found between the post-test scores of the students in the experimental and control groups in favor of the students in the experimental group ($U=247.00$; $p<0.05$) (Table 6). Accordingly, it can be inferred that the variability observed in the students' academic achievements is due to the educational comics used as instructional materials. Thus, it can be concluded that the teaching delivered by using the educational comics were more efficient in terms of academic achievement compared to the teaching delivered in the control group.

Discussion

Due to the individual differences of students in an educational environment, their perceptions and speeds of learning are different. The methods through which each student comprehends information also differ. Some students learn better visually, some by hearing, and some by writing. At this point, it can be said that the materials used are effective elements in learning (Chamisijatin et al., 2020; Fennema, 1972). As stated in Dale's Cone of Experience, which has been used in many studies in the literature, the increase in the number of sensory organs involved in learning makes learning more permanent. Therefore, the use of materials in science lessons is very important. Using educational comics as materials in lessons creates an enjoyable and remarkable learning environment for students at all levels of education (Badeo & Koc, 2021; Di Fuccia et al., 2012; Orçan, 2013). Comics make students more active in finding solutions to the problems they encounter in daily life (Putranta & Supahar, 2019). Daily language and life-like plots used in comics facilitate the learning of complex and abstract concepts (Lin et al., 2015).

The study aims to investigate the effects of comics created using the Web 2.0-supported applications Storyboard That and Canva in science classes on the academic achievement related to the subjects of "Food chain and energy flow" and "Energy transformations" at the 8th grade level. At the beginning of the study, an academic achievement test was developed for the relevant subjects and with the help of this test, the academic achievement pre-test scores of the control and experimental groups were compared. The results revealed that the academic achievement levels of the group that received science education with the created comics and the academic achievement levels of the group that received traditional science education were equal to each other (Table 3 and Table 4). After the implementation of the designed material, it was determined that there was a significant difference between the post-test scores of the groups in favor of the experimental group (Table 6). Therefore, it was concluded that the educational comics positively affected the accomplishment of the relevant objectives of the unit "Energy Conversions and Environmental Science". When it is not possible for students to make observations, it becomes difficult for them to make sense of some concepts in their minds. These concepts were visualized with the designed comics, making it easier for students to understand and learn the subject.

The use of comics in science education, which is the subject of the current study, has been tested with students in different subject areas and age groups, and similar results have been obtained. It has been concluded that using comics in science lessons increases students' desire to learn the subject and positively affects their attitude toward the lesson (Hermita et al., 2020; Hughes et al., 2011). Krishnan and Othman (2016) investigated the effectiveness of using educational comics as a learning tool in teaching science at the primary school level. The results of the study, conducted with 5th grade students using a quasi-experimental design, confirmed that using educational comics in teaching the subject of energy significantly increased students' achievement and their higher-order thinking skills. In the study conducted by Lin and Lin (2016), it was revealed that comics were more effective in student achievement than traditional science education. Another study investigating the effects of comics on science education concluded that comics were effective in teaching science, finding significant differences in students' pre-test and post-test understanding of science learning (Maryani & Amalia, 2018). Koutnikova (2017) stated that educational comics make the phenomenon of science more interesting. In a qualitative study conducted by Akcanca (2021), it was stated that comics concretize concepts in science classes and are a tool that should be used for effective teaching in schools. In a study using comics in

chemistry teaching, it was emphasized that they entertain students and that every teacher should use them (Weber et al., 2013). In a similar study, Arslan and Akçay (2022) suggested that comics could help students better understand some topics in biology. When the literature is examined, many studies, such as our study, indicate that comics can have a positive effect on the success of science teaching (Badeo ve Koc, 2021; Chamisijatin et al., 2020; Hermita et al., 2020; Hosler & Boomer, 2011; Matuk et al., 2021; Orçan, 2013). In addition, many studies reveal the effects of comics on the teaching process in fields other than science education (Akdağ, 2023; Arı et al., 2019; Canbulut, 2022; Efecioğlu, 2013; Gülersoy & Türkal, 2020; İlhan, 2016; Şeker, 2023; Şentürk, 2020; Tek, 2023).

Suggestions

According to the results of the study, it was revealed that comics created with the Web 2.0 tool had a positive effect on students' academic success in science. Based on this result, it is recommended that teachers who aim to increase student success in science classes should use educational comics in the science teaching process. In addition, it can be said that digital comics can be an effective tool in increasing the participation of students who are not interested in science classes thanks to the visuality, fluency, and easy comprehensibility they provide.

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Conflicts of Interest

No potential conflict of interest was reported by the authors.

Ethics

The ethics application for the study was made on 21/10/2022 and the research was carried out with the approval of Nevsehir Haci Bektas Veli University Ethics Commission dated 26/12/2022 and numbered 2022.13.429.

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