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The Effect of Animated Teaching on Science Teacher Candidates' Chemistry Achievements and Learning Persistence

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Abstract

The purpose of this study was to determine the effect of teaching with animation on chemistry achievement and learning persistence on pre-service science teachers studying in the undergraduate program of science teaching. The quasi-experimental model, one of the quantitative research approaches, was used in the study. The pretest-posttest was applied with the experimental control group. Eighty-two pre-service teachers, randomly selected with the appropriate sampling method, participated in the research. The "General Chemistry Achievement Test" developed by Sönmez (2017), which has validity and reliability in the literature, was used as a data collection tool. In addition, to determine the persistence of learning, chemistry achievement test post-test applications were applied again at six-week intervals. The data obtained from the findings was analyzed using descriptive and inferential statistical techniques in the SPSS 23.0 package program. Because the collected data did not have a normal distribution, the research conducted using nonparametric test techniques (Mann Whitney U and Kruskal Wallis) revealed a significant positive difference in favor of the experimental group to which animation was applied. In addition, in terms of gender variables, it has been determined that women have a higher mean than men. In contrast, there was no significant difference in grade level between teacher candidates. Following a six-week persistence test, it was found that there was a significant and positive correlation, ensuring the learning's persistence.

Keywords: Animation, chemistry achievement, science education

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Introduction

In the globalizing world, science and technology are changing people's lifestyles and perspectives on life more and more every day. As a result, countries now consider developed and qualified labor and raise qualified individuals. Today, which is called the 21st century, many skills individuals need to acquire have begun to come to the fore. Among these skills are critical thinking, stress management, multi-criteria decision-making, creative and reflective thinking, and computer and technology literacy (Ayyıldız & Yılmaz, 2021). In addition, as it is known, methods such as animation, simulation, digital technology-based teaching (Demirkan, 2019) and science center visits are generally teaching techniques that provide permanent learning and have a high retention rate.

Although there are many ways to grow qualified individuals (learning by doing, being a role model, learning on the job in applied professions, etc.), the best one is to grow individuals through education (Akçay, 2019; Gibson, 2012).

Individuals can develop and change in a systematic, programmed, and specific curriculum under legal guarantees with education. The education process has different areas, from pre-school to higher education, and has many stages (Jorde & Dillon, 2012). Social studies, classroom teaching, mathematics teaching, physics teaching, biology teaching, science teaching, and chemistry teaching (Kousa et al., 2018). Science teaching comes to the fore once more in these fields. It has a multidisciplinary structure and has an important place in individuals' understanding of the society and environment in which they live, making science teaching a little more prominent (Lai & Viering, 2012; Robin, 2008).

Many approaches are used in science teaching today (Sözbilir, 2017). These approaches can be classified as traditional, contemporary, and complementary approaches. While traditional technics are predominantly teacher-centered, they are teaching styles. Students are primarily passive and subject to a rote-based learning process (Patton, 2014; Roblyer, 2006). In contemporary approaches, on the other hand, although there is a teacher and student-centered education process, the teacher is in a more guide and guiding position (Jung & Brady, 2020). Artificial intelligence, context-based learning, brain-based learning, out-of-school learning, game-based learning, mobile learning, animation, simulation, teaching with analogies, and the use of mind maps are some of these methods (Çevik & Şenturk 2019; Ebersole, 2019; Genç, 2013). The REACT model, concept maps, portfolios, project-based learning, animation, simulation, video, and multimedia methods.

The 21st century can be called the digital age or the era of digital applications. The incredible transformations in information technologies, especially after the 2000s, encourage us to feel technology in every part of our lives and use it at a level that we often have to (Burgess & Sievertsen, 2020). Technology has entered our lives, undoubtedly affected education systems and teaching

programs and making it necessary to include technology-based applications in this process (Conejar & Kim, 2014; Eryaman, 2007). Especially in the science education process, many dangerous applications within the scope of physics, biology, and chemistry courses should be made in the laboratory environment with simulation and animation providing many conveniences and advantages in terms of time, effort, and health.

Chemistry teaching, which is carried out using the multimedia method with animation content, is very advantageous. Plus, it's simple and easy to include in the training process. When the necessary infrastructure or appropriate laboratory conditions are not available, computer-aided teaching methods with animation content can be highly beneficial to both educators and students. When looking at the research, it is clear that the animated teaching method is widely used in science education, particularly in chemistry, because it provides a rich learning environment in terms of both safety and auditory, visual, and multimedia. Students can also use the animation contents to practice continuously, test their hypotheses through trial and error, gain scientific process skills, develop critical thinking, and make multi-criteria decisions. Simultaneously, students can use advanced technology through applications and animations to the point of being computer and technology-literate individuals (Daldal, 2010).

In recent years, educators have started to use dynamic content provided by computer animations very often. Because instead of using static pictures or graphics in animations, the temporal change can be seen directly by moving objects. Moreover, the animation is not just used to express surreal actions or construct creative scenarios. It can also be used, for example, to facilitate the understanding of chemical concepts (Yılmaz & Bayrakçeken, 2017) or to monitor the movements of atoms and molecules more closely. Thus, the difficulties experienced by the students in the lessons are reduced and the teaching becomes livelier and more attractive (Lowe & Schnotz, 2008).

The importance of the research

Chemistry education is critical for understanding life and making sense of the environment in which people live. Moreover, because we encounter many chemistry-related events in our daily lives, many are related to matter and materials. In this context, a suitable laboratory environment or well-prepared learning environment should be prepared for qualified chemistry teaching. Therefore, many studies on chemistry teaching and the computer-assisted instruction method have been published in the literature (Ertan, 2019). In addition, studies on analogy, animation, simulation, and computer-assisted instruction methods (Abraham et al., 2015; Acevedo-Rocha et al., 2021; Akçay, 2019; Bell & Trundle, 2008), conceptual change, concept map, animation apps. etc. studies involving applications (Larwin and Larwin, 2011; Turan-Oluk, 2016), Studies on chemistry achievement (Günter, 2018), attitude and logical thinking disposition (Akıncı, 2019; Battal, 2020; Gökçe, 2015; Taşkın, 2019), Studies on the effect of model applications on learning products (Çevik, 2018; Öztürk & Doymuş,

2018; Tombul, 2019), Studies on the REACT strategy and the 5E model (Çevik, 2017; Danacı, 2018), Studies on computer-assisted instruction supported STEM activities and creativity applications (Tosun, 2019).

Purpose of the research

This study is expected to contribute to the literature by providing students with more than one skill type and permanent chemistry teaching in the distance education process applied due to the Covid-19 pandemic. It is also considered important as a guide for future research. In this context, answers to the following sub-problems were sought in the study:

1. Is there a statistically significant difference between the experimental and control groups' achievement test pre-test scores?

2. Is there a statistically significant difference between the experimental and control groups' achievement test post-test scores?

3. Is there a statistically significant difference between the experimental group's achievement test pre-test and post-test scores?

4. Is there a significant difference between the participants in the control group's achievement test pre-test and post-test scores?

5. Regarding the gender variable, is there a significant difference in the achievement test post-test scores of the experimental and control groups?

6. Regarding the grade level variable, is there a significant difference between the experimental and control groups' achievement test post-test scores?

7. What degree of correlation between the experimental group's achievement test post-test and retention test scores?

8. What is the level of correlation between the achievement test post-test and the retention test scores of the control group participants?

9. What is the level of correlation between the experimental and control group participants' retention test scores?

Method

Semi-experimental design was preferred as a research method. Experimental designs are frequently preferred in studies where certain variables are kept constant or controlled (McMillan & Schumacher, 2009). The research process applied pre-test, post-test, experimental, and control group

components. Science teacher candidates' chemistry achievements and learning persistence were examined using animation techniques in science lessons. Firstly, students were selected for the experimental and control groups in this context. Then the experimental group students were given animation. Finally, "the control group students" were taught "the traditional method" for six weeks.

Sample Group

The research sample group consists of 82 teacher candidates enrolled in the science teaching program. A convenient sampling method was preferred when determining the study group. The convenient sampling method saves the researcher time, effort, and money while providing an accessible sample (Fraenkel & Wallen, 2003). In addition, many studies with appropriate samples can be found when looking through the literature. Table 1 shows the demographic characteristics of the study group.

Table 1. Demographic Characteristics of the Sample Group

Variable	Sub Variable	Frequency	Percent
Gender	Female	44	53.66
	Male	38	46.34
Grade Level	1st grade	20	24.39
	2nd grade	16	19.51
	3rd grade	24	29.27
	4th grade	22	26.83
	Total	82	100

Table 1 shows that the grade level variable is examined, it is found that 24.39 percent (n=20) of 1st-grade students, 19.51 percent (n=16) of 2nd-grade students, 29.27 percent (n=24) of 3rd-grade students, and 4th-grade students fall into this category. It is seen that the rate of those found is 26.83% (n=22). While determining the experimental and control groups, a classification was made to include 41 participants with similar characteristics in both groups.

Data Collection Tools

Chemistry Achievement Test

An achievement test with validity and reliability in the literature was used during the research process. In this context, a chemistry achievement test developed by Sönmez (2017) consisting of 21 questions, open-ended questions, and multiple-choice was applied. Before using the said achievement test, necessary expert opinions were taken. "The Cronbach's Alpha" reliability coefficient was 0.86 in the chemistry achievement test pilot study. This rate is well above the safety level of 0.70 in studies

conducted in social sciences (Babayi & Hammanjulde, 2018; Kousa et al., 2018; Tabachnick & Fidell, 2007) is suitable for use.

Persistence Test of Learning

The chemistry achievement test was given six weeks after the post-test application to determine the persistence of the education process in which animation techniques were used in the research. The test was then used once more. In the findings section, the obtained results are presented in detail.

Data Analysis

The data subjected to descriptive and inferential statistics applications were analyzed using quantitative techniques. Data is collected, processed, summarized, and interpreted in the descriptive analysis. In contrast, inferential analysis examines the relationships between the variables belonging to the sample. First, it was reviewed whether the distribution of the data was expected. Shapiro-Wilk and Kolmogorov-Smirnov tests were applied for normality distribution (Can, 2016). In this context, "Mann-Whitney U Test" and "Kruskal Wallis Test," which are nonparametric tests, were used because the data did not show normal distribution (Büyüköztürk, 2010). In the persistence test results analysis, the correlation technique was used. The chemistry achievement test post-test and the learning persistence test were evaluated together.

Data Collection

During the application process, necessary permissions were first obtained from the relevant authors, the institution where the application was made, and the participants for the data collection tool. Then, information about the applications was given for a week, and pre-test applications were carried out. During the next six weeks, lessons were taught with animation techniques in the experimental group, and chemistry was taught with traditional teaching in the control group. While organizing animation activities, image editing applications, presentation applications, some Web 2.0 tools, and Flash and similar animator applications were used. In the eighth Week, post-test applications and general evaluation were made. Finally, the retention exam was given six weeks following the post-test applications. The findings section contains the findings. The application schedule is shown in Table 2.

Table 2. Implementation Schedule

Weeks	Activities
1	Information and pre-test applications
2	Activity 1. The structure of the atom and atomic models
3	Activity 1. Periodic table
4	Activity 1. Chemical compounds
5	Activity 1. Chemical reactions
6	Activity 1. Acids and bases, solutions
7	Activity 1. Thermodynamics
8	Activity 1. General evaluation and post-test applications
…	A waiting period of 6 weeks was realized.
14th Week	Persistence test applications

Results

Obtained findings were analyzed sequentially by considering the problem situation before delving into the research's subproblems, whether the normal data distribution was determined. In this context, "Shapiro-Wilk" and "Kolmogorov-Smirnov" tests were applied to control the assumption of normality (Can, 2016). Table 3 shows the results of the normality distribution.

Table 3. Normality Distribution Results

Groups	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistics	Df	p*	Statistics	Df	p*
Control Group Achievement Pre-Test	0.150	390.000	0.011	0.960	390.000	0.000
Control Group Achievement Posttest	0.193	390.000	0.001	0.883	390.000	0.004
Experimental Group Achievement Pre-Test	0.138	390.000	0.038	0.951	390.000	0.017
Experimental Group Achievement Post-Test	0.117	390.000	0.024	0.950	390.000	0.001
Control Group Retention Test	0.244	390.000	0.000	0.908	390.000	0.001
Experimental Group Retention Test	0.134	390.000	0.013	0.959	390.000	0.019

*p<0.05, Df: Degrees of freedom

When looking at Table 3, which contains the normality distribution results, it can be seen that the experimental and control groups' achievement and persistence test results did not provide the

normality distribution. Since the significance value p=0.05 was significant in all tests, parametric tests were used instead of nonparametric tests.

Sub-Problem (1)

"Is there a significant difference between the achievement test pre-test scores of the participants in the experimental and control groups?" was the study's first sub-problem. Table 4 shows the Mann-Whitney U test results in this context.

Table 4. Findings on the first sub-problem

Mann-Whitney U Test Findings						
Variable	Sub-variable	Rank Average	Rank Sum	U	p^*	Difference
Achievement Pre-Test	Control	36.49	1423.00	643.00	0.239	-
	Experiment	42.51	1658.00			

*p>0.05

Table 4 shows that the experimental and control groups' chemistry achievement test pre-test scores are not significantly different (p=0.239>0.05). The experimental and control groups of science teacher candidates had similar knowledge levels and participated equally in the research.

Sub-Problem (2)

"Is there a significant difference between the achievement test post-test scores of the experimental and control groups?" is the research's second sub-problem. In this context, Table 5 contains Mann-Whitney U Test results.

Table 5. Findings on the second sub-problem

Mann-Whitney U Test Findings						
Variable	Sub-variable	Rank Average	Rank Sum	U	*p*	Difference
Achievement Post-Test	Control	25.41	991.00	211.00	0.000	E > C
	Experiment	53.59	2090.00			

p<0.05. Experimental Group=E, Control Group=C

When the chemistry achievement test post-test scores of the experimental and control groups were compared in Table 5, it was discovered that there was a significant difference (p=0.000<0.05) between the experimental and control groups' chemistry achievement test post-test scores. This difference favored the experimental group. The activities resulted in a change in the knowledge levels of the science teacher candidates in both the experimental and control groups, with the experimental group showing a more significant change.

Sub-Problem (3)

"Is there a significant difference between the chemistry achievement test pre-test and post-test scores of the participants in the experimental group?" is in the form. In this context, Table 6 contains the Mann-Whitney U test results.

Table 6. Findings on the third sub-problem

Mann-Whitney U Test Findings						
Variable	Sub-variable	Rank Average	Rank Sum	U	*p*	Difference
Experimental Group	Pre-Test	20.19	787.50	7.50	0.000	Post > Pre
	Post-Test	58.81	2293.50			

p<0.05, Pre-Test=Pre, Post-Test=Post

When Table 6 was examined, it was found that there was a significant difference between the pre-test and post-test scores of the chemistry achievement test pre-test and post-test scores of the experimental group pre-test and post-test scores (p=0.000<0.05), with the experimental group post-test scoring higher. It means that, compared to the initial level, the experimental group's science teacher candidates' knowledge levels changed due to the activities. This change favored the post-test, i.e., based on the outcomes of the applications.

Sub-Problem (4)

"Is there a significant difference between the chemistry achievement test pre-test and post-test scores of the participants in the control group?" is in the form. Table 7 contains the "Mann-Whitney U Test" results in this context.

Table 7. Findings on the fourth sub-problem

Mann-Whitney U Test Findings						
Variable	Sub-variable	Rank Average	Rank Sum	U	*p*	Difference
Control Group	Pre-Test	20.15	786.00	6.00	0.000	Post > Pre
	Post-Test	56.15	2295.00			

p<0.05, Pre-Test=Pre, Post-Test=Post

When Table 7 was examined, it was found that the pre-test and post-test scores of science teacher candidates in the control group differed significantly (p=0.000<0.05). After the post-test, this difference favored the control group. It means that the pre-service teachers in the control group's knowledge levels changed due to the activities compared to their initial levels. This change was again in favor of the post-test, based on the application results.

Sub-Problem (5)

"Is there a significant difference between the chemistry achievement test post-test scores of the participants in the experimental and control groups in terms of gender?" is in form. In this context, Table 8 contains Mann-Whitney U Test results.

Table 8. Findings on the fifth sub-problem

Mann-Whitney U Test Findings						
Variable	Sub-variable	Rank Average	Rank Sum	U	*p*	Difference
Gender	Female	49.25	2355.00	8.50	0.003	F > M
	Male	36.15	1245.00			

p<0.05, Female=F, Male=M

When looking at Table 8, it was found that there was a significant difference in gender between the pre-service teachers' chemistry achievement test post-test scores in the experimental and control groups (p=0.003<0.05). This disparity was in females' favor. From this, it can be seen that the achievements of female participants in the study outnumber male participants.

Sub-Problem (6)

"Is there a significant difference between the chemistry achievement test post-test scores of the participants in the experimental and control groups in terms of the grade level variable?" is in the form. In this context, the "Kruskal Wallis Test" results are in Table 9.

Table 9. Findings on the sixth sub-problem

Kruskal Wallis Test Findings						
Variable	Sub-variable	Rank Average	Df	X2	p	Difference
Grade level	First-grade	66.74	3	42.211	0.002	3 > 2 3 > 1
	Second-grade	65.41				
	Third-grade	78.26				
	Fourth-grade	69.41				

p<0.05, Df: Degrees of freedom

Table 9 shows that in terms of grade-level variables, there is a significant difference between the chemistry achievement test post-test scores of science pre-service science teachers in the experimental and control groups (p=0.002<0.05). This difference is between 3rd grade and 1st grade and 3rd grade. Therefore, it was determined to be among the 2nd class and favoring the 3rd class. This shows that the chemistry achievement test results of the 3rd-grade pre-service science teachers are higher and more significant than the pre-service science teachers at the other grade level.

Sub-Problem (7)

"How is the correlation level between the chemistry achievement test post-test and retention test scores of the participants in the experimental group?" is in the form. In this context, Table 10 contains Spearman's Rank Correlation (Spearman's Rho) analysis results.

Table 10. Findings on the seventh sub-problem

Experimental Group Achievement Test and Persistence Test Post-test		
Variables	Rank	(r=Points)
Spearman's Rho	Correlation (Value) Coefficient	0.751**
	p	0.000
	N	41

**p<0.01 *p<0.05 significance level

When Table 10 was examined, it was found that the chemistry achievement test post-test scores and the retention test score of the pre-service science teachers in the experimental group had a significant and positive correlation of r=0.751 p=0.000. It is shown that animation techniques and chemistry teaching give pre-service science teachers permanent learning.

Sub-Problem (8)

"How is the correlation level between the chemistry achievement test post-test and retention test scores of the participants in the control group?" is in the form. In this context, the Spearman Rank Differences Correlation analysis results can be found in Table 11.

Table 11. Findings on the eighth sub-problem

Control Group Achievement Test and Persistence Test Post-test		
Variables	Rank	(r=Point)
Spearman's Rho	Correlation (Value) Coefficient	0.409*
	p	0.003
	N	41

**p<0.01 *p<0.05 significance level

When Table 11 was examined, it was found that the chemistry achievement test post-test scores and the retention test score of the pre-service science teachers in the control group had a significant and positive correlation of r=0.409 p=0.003. This situation shows that pre-service science teachers ' teaching chemistry with traditional teaching methods has a permanent effect.

Sub-Problem (9)

"How is the correlation level between the retention test scores of the participants in the experimental and control groups?" is in the form. In this context, Table 12 contains Spearman Rank Differences Correlation analysis results.

Table 12. Findings on the ninth sub-problem

Experimental and Control Group Persistence Test		
Variables	Rank	(r=Point)
Spearman's Rho	Correlation (Value) Coefficient	0.446**
	p	0.001
	N	41

**p<0.01 *p<0.05 significance level

When Table 12 is examined, it is found that the retention test scores of science teacher candidates in the experimental and control groups have a significant and positive correlation of r=0.446 p=0.001. This shows that pre-service science teachers' teaching chemistry with animation techniques and traditional methods has a persistent effect.

Discussion, Conclusion and Recommendations

When the literature is examined, it is seen that the studies carried out within the scope of computer-assisted teaching methods (such as animation and multimedia techniques) and chemistry teaching primarily cover the studies at primary, secondary, and high school levels. They are carried out in educational environments with complementary approaches and face-to-face environments rather than contemporary and traditional studies (Barrot, 2021). Furthermore, the CAI method was fully implemented with remote access, which is an outstanding aspect of this research. Moreover, applications were carried out within the scope of mandatory distance education during the COVID-19 pandemic period. In this regard, the study is expected to contribute to the literature because it is appropriate for the nature of the animation, presentation, and computer-assisted instruction method (Öztürk, 2021) and is, in many ways, both developer and application-oriented.

This study, which examines the effects of pre-service science teachers' animation techniques and chemistry teaching on chemistry achievement and persistence, supports the literature (Jamil & Yasak, 2021). The results are given in detail in the findings section. However, some results that overlap and differ from the literature are discussed below.

The chemistry achievement test post-test scores of science teacher candidates in the experimental and control groups were significantly different (p=0.000<0.05). This difference was in

the experimental group's favor. In addition, it was discovered that there was a significant gender difference in the academic achievement test post-test scores of science teacher candidates in the experimental and control groups ($p=0.003<0.05$). Again, this difference was in favor of women. The literature shows that women's analytical and critical thinking skills are generally higher than men's (Koçak, 2014).

It was known that internet supported teaching method was more effective on students' academic achievement than traditional teaching methods and had a positive effect on their attitudes towards science and technology class, questioning learning skills and concept perceptions. Furthermore, several studies in the literature show that social network-based learning environments (Ünal & Yerlikaya, 2021); science-technology-society approach (Çınar & Çepni, 2021); computer-assisted instruction (Nkemdilim & Okeke, 2014) and modelling-based conceptual learning (Okumuş, Koç & Doymuş, 2019) positively influence students' attitudes toward the related course or learning environment. These researches are consistent with our study and, in some ways, support our findings.

In terms of grade-level variables, there was a significant difference between the science teacher candidates' post-test scores on the chemistry achievement test in the experimental and control groups ($p=0.002<0.05$), with the difference favoring the third grade. Considering that third-year students have more academic experience than first- and second-year students, it is seen that the grade level variable is naturally more significant (Ültay, 2012). On the other hand, it is typical for the grade level variable of the third graders to be more significant in terms of the fourth graders being busy with activities such as graduation, teaching practice, and teaching proficiency exams. It was found that the post-test scores on the chemistry achievement test and the retention test scores of pre-service science teachers in the experimental and control groups had a strong and positive correlation. It is seen that the correlation results for both traditional and animation techniques are significant and positive. However, while the correlation for animation is about 75%, it is seen that the correlation found according to the traditional method is about 40%. These results are similar to many studies in the literature (Ağlarcı, 2014). In addition, similar to this study, some studies on chemistry education conducted with computer-aided teaching, including multimedia techniques such as animation, and presentation are shown below;

Daldal (2010) examined the effect of the computer-based method on students' academic achievement within the scope of the general chemistry course. It was stated that the experimental model was used in the study. Before the application, the readiness test was applied to the experimental and control groups. Gökçe (2015) examined the effect of the computer-based teaching method on the acids-bases unit and the impact on student's academic achievement, logical thinking, and attitudes. In the research process, quasi-experimental design, one of the quantitative research approaches, was used. As a result of the research, it was stated that the achievement and attitude scores of the

experimental group in which the computer-based teaching method was used differed significantly compared to the control group, and there was no significant difference between the logical thinking ability scores at the level of the groups. In his study, Çevik (2017) examined the effect of the states of matter unit on students' academic achievement using the computer-based teaching method using the 5E model. The research was carried out in 12-course hours for six weeks. When the achievement test results were examined at the end of the application, it was stated that the computer-based teaching activities developed according to the 5E model created a significant difference in favor of the experimental group compared to the traditional teaching and revealed statistical significance. Danacı (2018) examined the effect of teaching the particulate structure of matter with the help of animation on students' academic achievement. In the study, traditional instruction was applied to the control group, and teaching with computer-based instruction-supported animations was applied to the experimental group. As a result of the research, it was determined that animation contributed positively to the students' academic achievement (Su, 2022).

Pamuk (2018) looked at the impact of computer-assisted instruction on academic achievement and attitudes toward periodic systems and chemical bonds. The research was conducted using a semi-experimental design. As a result of the study, it was discovered that using a computer to teach students made a significant difference in their academic achievement. Simultaneously, it was stated that it made no difference to their attitudes. Within the context of human and environmental relations units, Akncı (2019) investigated the impact of computer-based teaching methods on academic achievement. According to the findings, computer-based teaching methods resulted in a significant difference in academic achievement compared to traditional methods. Ergün (2019) investigated the impact of collaborative computer-based teaching on academic achievement and attitude in his research. One of the experimental methods used in the research was a quasi-experimental design with a pre-test, post-test experimental control group. When the research findings were compared to traditional approaches, it was discovered that the collaborative computer-based teaching method did not affect students' attitudes. Ertan (2019) investigated the effects of using a computer-based teaching method to teach the subjects of meiosis and mitosis on students' academic achievement. According to the findings, using computer software to teach mitosis and meiosis is more beneficial than traditional methods. Taşkın (2019) investigated the impact of dynamic and interactive science instruction on student achievement.

Tombul (2019) used modeling and a computer-based teaching method to examine the learning products of secondary school 7th-grade students in astronomy. According to the study's findings, students in the experimental group had a significantly higher average than those in the control group. In his research, Tosun (2019) investigated the effects of computer-based instruction-assisted STEM education. The study included six students with special needs. As a result of the study, it was discovered that students' participation rates in science classes increased, and they developed a positive

attitude toward science classes. In his research, Battal (2020) looked at the impact of computer-based teaching methods on students' math achievement. As a result of the study, New Zealand was determined to have the highest rate of computer use among 4th and 8th-grade teachers, while China and Turkey had the lowest rate. When the achievement and retention test results of science teacher candidates are examined, it can be concluded that both the experimental and control groups are significant and positive, with the experimental group having a decisive advantage.

For permanent chemistry teaching, it is preferred that the information components (text, picture, sound, video) used in the course materials are especially rich in terms of visual and multimedia. In this context, animation, simulation, etc. It is thought that learning realized by using techniques is more permanent. In addition, it is known that practice-oriented courses should be given with a student-centered approach, and students should be guided rather than loaded with information. This is possible with better training of prospective science teachers.

A limited number of computer applications were used in this study. In this sense, it can be suggested to use alternative and current applications to support teacher candidates' computer and technology literacy. Since computers, the internet, and multimedia technologies increase transferring knowledge and persistence in the teaching process (Ayyıldız, Yılmaz & Baltacı, 2021). They can be used in biology, physics, and other fields besides chemistry. Animation, simulation, analogy, presentation, etc., should be used in new studies so that teacher candidates can use methods such as computer software, web 2.0/web 3.0 technologies (Yanarateş, 2021), multimedia applications more actively when they start their profession. They can give more space to such applications and activities.

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