p-ISSN 2355-5343
e-ISSN 2502-4795
http://ejournal.upi.edu/index.php/mimbar

Article Received: 28/05/2022; Accepted: 19/01/2023
Mimbar Sekolah Dasar, Vol.10(1), 63-79
DOI: 10.53400/mimbar-sd.v10i1.46334

The Effect of Using Interactive Simulation in Science Laboratory on Knowledge Levels of Science Laws and Computational Thinking Skills

Nurhan Atalay[1] & Mehmet Mutlu✉[2]

[1,2] Niğde Ömer Halisdemir University, Niğde, Turkey

✉ mehmetmutlu@ohu.edu.tr

Abstract. Today, teaching strategies and methods changing with technology require a radical transformation in the teaching of science laws, which form the basis of science subjects. In this study, computational thinking skills, which will allow students to use information and communication technologies in today's conditions and the effect of these skills on their knowledge levels about science laws were examined. A university in the Central Anatolian Region of Turkey served as the institution that provided the study sample, which consisted of 61 science preservice teachers who were enrolled in the university's Science Teaching Department. In this study, pretest-posttest control group design, one of the experimental designs, was used. The participants were randomly assigned to either the experimental group or the control group, with 30 people assigned to the experimental group and 31 participants assigned to the control group. To collect data, an achievement test with 20 questions aiming to measure the success levels of science laws by the researchers and the "Computerized Thinking Scale" for university students was used. At the end of the research process, it was concluded that the achievements of the students in the experimental group were significantly different from the students in the control group, and there was a significant difference in favor of the experimental group in all sub-dimensions of computational thinking and computational thinking.

Keywords: Science laboratory, interactive simulation, computational thinking skill, science laws, preservice science teacher.

1. Introduction

With the changing and developing technology in today's information society, the needs of the learners in education are changing as well. Individuals who are learning are expected to be equipped with a variety of abilities in order to find a place in society, become productive citizens, and keep up with changing situations. These skills, known as 21st century skills are among those that must be learned at all stages of education, from basic school to university. Students will have to put their knowledge to use in a variety of dynamic situations. Empathy, self-efficacy, and collaboration are a few examples of the social and emotional skills they will require, but they'll also need practical skills and physical prowess, as well as cognitive and metacognitive abilities (e.g. using new information and communication technology devices) (OECD, 2018). In this respect, the 21st century has also changed the types of skills, knowledge and competencies required for success in the modern society. On the other hand, its comments on computational thinking (CT), the other hand, started as a way of thinking for computer scientists and became an essential skill for anyone who wants to advance in the world of technology and to solve problems effectively (Palts & Pedaste, 2020). Students nowadays are digital natives, having grown up with MTV video games, email, the internet, and instant messaging. Digital natives have distinct cognitive thinking habits than prior generations (Prensky, 2001). There has always been a need to strike a balance between technological advancement and instructional utility. The fundamental demonstration of this usefulness must be the consequences on users. In addition, building an educational process within the context of a complex technological world is a challenging journey in which we may gain insight from every decision we make (Cela-Ranilla & Esteve-González, 2015). Technology-supported learning tools in education are used in different ways by teachers and learners in the process and in learning environments.

1.1. Problem Statement

Changes, such as the enormous increase in information technology and computer use and the activities in this context, have begun to emerge. However, with the passing of time, an even more important change emerged. These changes are virtual realities with artificial intelligence and immersive interactive technologies as well as digital games and simulations Teachers must develop new instructional strategies, for today's youngsters who grew up with such devices (Baek, 2009). Innovative practices influenced not only the members of the academic community but also the teaching components and mechanisms. They form an important component of the teaching and learning process throughout time. Science instructors, for example, might profit from the usage of 3D simulations in laboratory studies and practical lectures (Al Musawi et.al. 2017). In traditional physics laboratories, the cookbook approach in the laboratory is followed. In these traditional laboratories, students are given a recipe to follow as well as specific questions to answer (Taibu, Mataka & Shekoyan, 2021). However, merely using computers in scientific classrooms does not guarantee spontaneous learning. Despite the increasing prevalence of information technology in the scientific classroom, there is no standardized structure in place to facilitate the effective transition to computer-enhanced courses. In order to contribute to meeting this need, the suggestion is firstly to design and develop science teaching and learning materials and secondly to expand this methodology by considering the effective inclusion of computer-based tools in the science curriculum (Papadouris & Constantinou, 2009). One of the environments in which students will be active and have experience in the process and use technology effectively in science lessons is laboratories.

1.2. Related Research

Simulation-based interactive multimedia, which provides experiences associated to relevant observations and processes, is one of the increasing learning environments currently. Experiential learning is meant to improve scientific knowledge and analytical ability, particularly for complex ideas like cell metabolism (Putri & Sofyan, 2020). Models and modeling (for example, simulations, analogies, maps, diagrams, and graphs) are essential for the teaching of abstract topics. Models and modeling assist pupils in visualizing and concretizing abstract concepts, events, or processes in their brains. Models and modeling are critical in the learning and teaching of science since there are many abstract notions or processes. As a result, they are important to scientific education (Benzer & Ünal, 2021). Models and modeling are an integral part of science. Technological developments provide an environment for the development of models and the application of modellings in classrooms. Considering the benefits of technology-assisted model-based teaching, research is known as suitable environments for students to achieve the purposes of inquiry (Namdar, 2017). Given that science is mostly abstract, for its simulations (not visible to the naked eye), real-like experiences are thought to be extremely beneficial for non-abstract thinking (Putri & Sofyan, 2020). Simulations offer appropriate practice opportunities in contextualized learning environments, in real-life situations and in safe, reasonable, and sometimes even impossible situations (Becker& Parker, 2009). In this context, the research is very important in terms of revealing the effects of the use of interactive simulations in experiments related to real life events on computational thinking skills and knowledge levels, which are necessary skills to be acquired today.

1.3. Research Objectives

The primary goal of this study was to see if pre-service science teachers' use of interactive simulation in the science laboratory affected their level of understanding of scientific laws and computational thinking skills. In line with this purpose, the following sub-problems were investigated.

1.What is the difference between the experimental and control groups in terms of pre-service science teachers' understanding of scientific laws (such as newton's law of universal gravitation and the conservation of matter and energy, heat energy transformation in matter, and coulomb's law) as a result of the applications carried out using Interactive Simulation Teaching Experiments (PhET)?

2.As a result of the PhET applications, is there a significant difference in the computational thinking abilities of preservice science teachers between the experimental and control groups?

The results of this study will help reveal the effects of experiments with interactive simulations in the Science Laboratory on students' success and computational thinking skills. In this respect, the research results will contribute to promoting and disseminating the use of such interactive simulations, which will be an alternative to or a support to traditional laboratory practices.

2. Theoretical Framework

Simulations' contextual material enables learners to "learn by doing" (Kluge, 2007). According to Prensky (2001), learning by doing is at the center of game-based and simulation-based learning because the researcher points out that "doing" is a good feature of computer simulations and that it allows interacting with them. Of course, there are many ways to learn by doing. However, the important thing here is the active participation of the student. Simulations may be used to create an interactive, immersive world in which users can experiment with and feel the consequences of their choices. They may have access to experiences that are not available in real life, such as journeying through space or gazing inside a blood cell. They may also allow individuals to study frog anatomy without actually killing a frog or practice first-aid methods in the case of a hazardous material incident without putting themselves in real danger (Becker & Parker, 2009).

Students should be encouraged to use virtual worlds, simulations, and digital games to increase their classroom productivity. Digital simulations are often used in situations where physical security is a concern, because they can be used to create an illusion of safety. In the actual world, computer simulations can be used to replace costly or dangerous situations. Furthermore, students like digital simulations because they motivate them to participate in activities involving decision-making. These are just a handful of the numerous reasons why digital simulations have always been beneficial in the classroom. When paired with traditional lectures and conversations, the educational benefits of employing digital simulations are numerous. Visual learners are given the opportunity to "see" a process rather than merely hearing about it (Baek, 2009). Simulations are always interactive, allowing students to change model variables and observe how their changes affect the simulated system. In addition, they can be used as animations to help students visualize complex ideas. In this approach, students are introduced to virtual experiments, which are a strong instrument for examining, studying, and linking natural phenomena, as opposed to passive observation of the execution of the depicted experiments (Papadouris & Constantinou, 2009). According to Strogatz (2007), computer simulation is a computer program that seeks to imitate an abstract model of a given system. It is a computer software program that may be used to simulate the behavior of a computer network, and it has become an important aspect of the mathematical modeling of many natural systems in physics.

Simulations, according to Bell and Smetana (2015), may depict a simplified version of a real-world component, event, or concept through animation and visualization as well as interactive laboratory experiments. There are a wide range of skills that are necessary, including scientific literacy, scientific process skills, spatial aptitude, and problem-solving abilities, and logical reasoning. It is not only necessary, but it also helps to develop these skills (Benzer & Ünal, 2021).

PhET simulation can be a virtual lab where students can take an active role in conducting virtual experiments and exploring physics concepts. As with any learning tool, PhET simulations need to be carefully integrated into the curriculum. With this approach, learning is made more fun and more effective with PhET application simulations tools (Wieman et.al., 2010). PhET simulations are customizable learning tools that allow students to choose their own learning routes while simultaneously applying constraints to guarantee that their choices are usually productive. Using this method of inquiry, students will be able to make sense of and link many representations and occurrences, including clear ties to the actual world and representations not found in the real world (Podolefsky, Perkins and Adams, 2010). PhET stands for Physics Education Technology developed by the Physics Education Research (PER) group from the University of Colorado in the United States. PhET simulation provides interactive, fun, meaningful, highly informative research-based computer simulations of physical phenomena for free. It covers key subjects in Earth Science, Biology, Chemistry, Physics and Mathematics. PhET has been carefully designed and tested to support students' visual understanding of concepts. By making use of intuitive controls such as graphics, it brings things invisible to the human eye. In addition, the simulation offers measuring instruments, including ammeter and voltmeter. As students manipulate interactive tools, they see animated responses illustrating cause-effect relationships and multiple connected representations. When combined with guided inquiry activities that help students to create their own knowledge, simulation has shown to be very beneficial (Potane & Bayeta, 2018).

2.1. Computational Thinking

Computer Thinking (CT) is seen as a vital skill necessary to prepare for the future. However, teachers, particularly teachers and researchers in grades K-12, have not specified how to teach it effectively (Hsu, Chang and Hung, 2018). Although computational thinking overlaps significantly with computer science on certain elements, unlike computer science, they mainly focus on developing and disseminating problem solving approaches (Cansu & Kılıçarslan-Cansu 2019). Computational thinking is a problem-solving technique that uses abstraction, decomposition, generalization, and algorithm design to define solutions. The process is comparable to that used in software development and yields results that are relatively simple to implement by humans or robots. (Mvalo & Bates, 2018). Computational thinking is also known to refer to a generally applicable mindset and skill set that comprises a set of mental tools, problem solving that covers the design of systems and the understanding of human behavior, which can be learned and used by everyone, not just computer scientists (Wing, 2008). Individuals' cognitive skills and processes are often the subject of computational thinking. As a result, computational thinking exercises are primarily intended to develop cognitive skills and promote teaching and learning processes in afflicted persons (Cansu & Kılıçarslan-Cansu,, 2019). In the light of previous research, in this study, it is aimed to better understand and reveal the effects of using PheT interactive simulations, which provide an environment for intervention by transferring the models to the digital environment, on the students' understanding of science laws and their computational thinking skills at the higher education level. The findings from our research are expected to be a resource for further research on interactive simulations in laboratory settings.

3. Method

3.1. Research Design

An experimental model with a pretest-posttest control group (one experimental group and one control group) was constructed in this study to test the efficiency of applications conducted with the use of teaching experiments based on Interactive Simulation (PhET). With unbiased assignment, two groups are produced in this approach. One serves as the experimental group, while the other serves as the control group. Pre- and post-experimental measurements are taken in both groups (Karasar, 2004). In the experimental group, teaching experiments based on Interactive Simulation (PhET) were conducted, while traditional laboratory processes were performed in the control group. In the study, the academic achievement test consisting of 20 comprehension questions developed by the researchers in relation to the Laws of Science (Conservation of Energy, Conservation of Matter, Transformation of heat energy in matter which was taught during the research process, were applied to both groups prior to the experiment procedures began (pretest) and after the experimental procedures concluded (posttest). Moreover, in the study, the "Computational Thinking Scale" developed by Korkmaz, Cakır, and Ozden (2017) for university students were applied. The application phase of the study lasted eight weeks in both groups. The outcomes of the pre-test and post-test were examined using the appropriate statistical techniques.

3.2. Study Group

In the Central Anatolian Region of Turkey, there were a total of 61 preservice teachers of third-grade science who were enrolled in a program offered by a university. Of these, 30 were assigned to the experimental group, while 31 were assigned to the control group. Due to the fact that the results of the pre-test indicated no significant differences between the two groups, the experimental group and the control group were both taught by the same instructor, and their assignments were chosen at random.

3.3. Data Collection

As a study data gathering instrument, the academic achievement test made up of 20 comprehension questions developed by the researchers regarding the subjects of Science Laws and the "Computational Thinking Scale" developed by Korkmaz, Cakır, and Ozden (2017) for university students were used.

3.3.1. Science Laws Achievement Test (SLAT)

The accomplishment exam utilized in the study was created by the researchers by taking into account the outcomes of the science curriculum and including the basic concepts of "Science Laws (Conservation of Energy, Conservation of Matter, Transformation of heat energy in matter, Coulomb's law, Newton's Law of Universal Gravitation, and Ohm's Law)" taught to preservice teachers in the experimental and control groups for eight weeks.

A multiple-choice accomplishment test, consisting of 20 questions with five options each, was created to test the study's sub-problems. Expert opinion was sought for the content validity of the 44-question accomplishment exam collected from materials certified as textbooks by the Ministry of National Education Board of Education and Discipline, and the researchers prepared a pre-application form. For the validity and reliability studies of the achievement test, it was applied to 101 university students who had taken the course of Science Laboratory before. As a result of the item analysis, 24 questions were excluded from the test because those with item difficulty indexes were above 0.8 and below 0.3 as well as because the item discrimination indexes were below 0.3, as stated by Atılgan, Kan, and Dogan (2009). The number of questions was reduced to 20 by performing item analysis with the TAP program (Test Analysis Program) (Brooks & Johanson, 2003). The reliability of the 20-question test obtained as a result of the analysis (Kr-20) was calculated as 0.76; the mean distinctiveness of the questions was .55; and the mean difficulty level of the questions was .51.

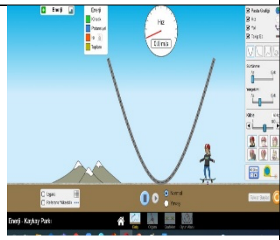
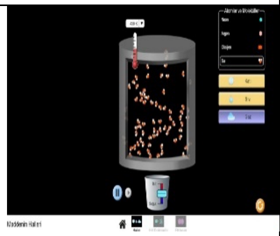
3.3.2. Computational Thinking Scale (CTS)

The "Computational Thinking Scale" established by Korkmaz, Cakır and Ozden (2017) was employed to measure the preservice teachers' levels of computational thinking skills (a=0.822). The scale was a five-point Likert-type consisting of 29 items and five factors. The factor called "Creativity" included 8 items with an internal consistency coefficient of 0.843. The factor of "Algorithmic Thinking" was made up of 6 items with an internal consistency coefficient of 0.869. The factor of "cooperation" consisted of 4 items with an internal consistency coefficient of 0.865. The factor of "Critical Thinking" included 5 items with an internal consistency coefficient of 0.784. The factor of "Problem Solving" included 6 items with an internal consistency coefficient of 0.727. Lastly, the internal consistency coefficient for the whole scale was 0.822. The necessary permission for the use of the scale was obtained before the application.

3.3.3. The Application Process

Experiments on conservation of energy, transformation of heat energy in matter, ohm's law, coulomb's law, Newton's law of universal gravitation and the law of conservation of matter were conducted by the experimental group for 8 weeks with the interactive simulation (PheT) program. The control group's pre-service science teachers, on the other hand, completed the learning process in accordance with traditional laboratory procedures.

Table 1. Application Process and The Weekly Work Plan

Weeks	Subjects	Experimental Group (PheT Simulations)		Control Group
Week 1		Application of pre-tests (SLAT-CTS)		Application of pre-tests (SLAT-CTS)
Week 2	Law of Conservation of Energy https://phet.colorado.edu/tr/simulations/energy-skate-park	Using the Phet app		Traditional Approach
Week 3	Transformation of heat energy in matter https://phet.colorado.edu/tr/simulations/states-of-matter	Using the Phet app		Traditional Approach

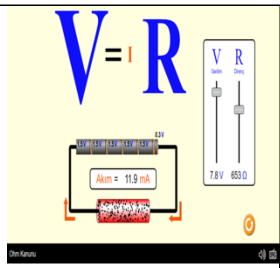
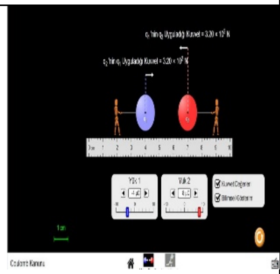
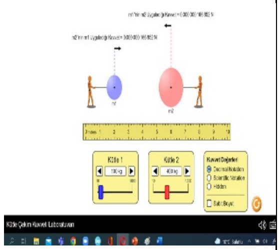
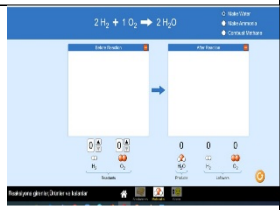
Week 4	Ohm's Law https://phet.colorado.edu/tr/simulations/ohms-law	Using the Phet app		Traditional Approach
Week 5	Coulomb's Law https://phet.colorado.edu/tr/simulations/coulombs-law	Using the Phet app		Traditional Approach
Week 6	Newton's law of universal gravitation https://phet.colorado.edu/sims/html/gravity-forcelab/latest/gravity-force-lab_tr.html	Using the Phet app		Traditional Approach
Week 7	Law of Conservation of Matter https://phet.colorado.edu/tr/simulations/balancing-chemical-equations	Using the Phet app		
Week 8		Application of post-tests (SLAT-CTS)		Application of post-tests (SLAT-CTS

Figure 1. Images of The Application Process

3.4. Data Analysis

The program IBM SPSS Statistics 24.0 was used in order to do the analysis on the data. Parametric statistics require the assumption of normality of the distribution. If there is insufficient evidence or lack of strong signs showing that the distribution is normal, or if the distribution is skewed, then non-parametric statistics should be used (Büyüköztürk, 2007). Due to the fact that there were less than fifty pre-service instructors, the Shapiro-Wilk normality test was employed to determine whether or not all of the data acquired from the dependent variables satisfied the normality assumption ($p>.05$) (Kalaycı, 2006). According to the Shapiro-Wilk test results, the Science Laws Achievement Test (SLAT) showed a normal distribution ($p>.05$). According to these results, for the SLAT (pretest and posttest) analysis, "t-test for independent groups (independent-Samples t-test)" was used when comparing the groups' results in the tests with each other. The students' pretest and posttest findings were examined using the IBM SPSS Statistics 24.0 package program, and the results were evaluated at the.05. significance level.

4. Findings

This section includes data analysis from the experimental and control groups, as well as interpretations of these analyses to test the study's sub-problems. In order to apply statistical analysis regarding the pre-test results in the study, first of all, it was necessary to investigate whether the test results showed a normal distribution. Therefore, the data were analyzed using the "Shapiro-Wilk Normality Test" (because the number of preservice teachers was below 50). Table-2 displays the results obtained.

Table 2. Shapiro-Wilk Normality Test Results

	Control Group						Experimental Group					
	N	$\overline{X}$	Ss	Skewness	Kurtosis	p	N	$\overline{X}$	Ss	Skewness	Kurtosis	p
SLAT Pre-Test	31	8.06	2.35	-.31	.400	.392	30	7.73	2.86	.231	-.760	.379
SLAT Post-test	31	12.61	2.24	.35	.416	.581	30	15.16	2.29	-.293	-.344	.546
CTS Pre-test	31	93.8	10.06	.121	.069	.205	30	92.40	6.74	-.407	-.424	.278
CTS Post-test	31	104.4	4.89	.38	.033	.514	30	115.33	5.79	.592	.259	.402

The skewness and kurtosis values of the distributions were examined for the assumption of normality test. The pre-test and post-test skewness values of the control and experimental groups varied from -.40 to +.59, as shown in Table 2. The Kurtosis values in the related tests for the same groups were between -.76 and +.41. As the Kurtosis and Skewness values are considered to be normal when they are between -1.5 and +1.5 (Tabachnick & Fidell, 2013). The outcomes of both the pre-test and the post-test are shown here. Distributions in this study were found to be close to normal. According to Table 2, it could be stated that all the test results for both groups had a normal distribution (p > .05). Normal distribution of pretest results that parametric tests may be run on the data. In this study, two types of parametric tests were used: the "dependent groups t-test" and the "independent groups t-test. SLAT was applied to compare the achievements of the students in the experimental and control groups before the experimental process regarding the subjects of Science Laws (Conservation of Energy, Conservation of Matter, Transformation of heat energy in matter, Coulomb's law, Newton's Law of Universal Gravitation and Ohm's Law). The results obtained from this application were compared with the independent groups t-test. The test results are given in Table 3.

Table 3. t-Test Results for Independent Groups Regarding Preservice Science Teachers' SLAT Pre-test Results in Experimental and Control Groups

Measurement	N	$\overline{X}$	Ss	Sd	t	p
Pre-test (Experimental)	30	7.73	2.86	59	-.494	.623
Pre-test (Control)	31	8.06	2.35			

When Table 3 was analyzed, it was revealed that the SLAT pretest mean findings of the experimental and control groups were extremely similar. The independent groups t-test was used to see if the difference between these mean results was statistically significant. The t value and significance level showed that there was no significant difference between the groups (t (59) =-.494; p >.05). Therefore, the groups were statistically homogeneous, and at the same time, the fact that the experimental-control groups' pre-test results related to the achievement test were at the same level allowed using the experimental method in the study. The fact that there was no significant difference between the achievements of the students before the application started served the purpose in terms of determining the effectiveness of the teaching method applied.

The pre-test results of the Computational Thinking Scale of the students in the experimental group, in which the PheT application was applied, are given in Table 4.

Table 4. t-Test Results for CTS Total and Sub-Dimension Pre-Test Results of Preservice Science Teachers in the Experimental and Control Groups

Dimensions	Measurement	N	$\overline{X}$	Ss	Sd	t	p
Creativity	Control Group	31	30.32	2.57	59	-.951	.345
	Experimental Group	30	29.80	1.58			
Algorithmic Thinking	Control Group	31	19.90	2.98	59	-.876	.385
	Experimental Group	30	19.23	2.99			
Cooperation	Control Group	31	13.80	2.45	59	.183	.855
	Experimental Group	30	13.96	4.18			
Critical Thinking	Control Group	31	15.32	1.92	59	-.106	.916
	Experimental Group	30	15.26	2.21			
Problem Solving	Control Group	31	12.67	3.26	59	-.249	.804
	Experimental Group	30	12.50	2.16			
CTS Total Score	Control Group	31	93.87	10.06	59	-.668	.507
	Experimental Group	30	92.40	6.74			

When Table 4 was analyzed, it was discovered that the total mean scores on the CTS pre-test that the preservice science teachers who were part of the experimental group and the control group obtained were relatively similar to one another. The independent groups t-test was used to determine whether or not the difference between these mean findings was statistically significant. According to the t value and significance level, there was not a significant difference detected between the groups ($t(59)=-.668$; p.05). The results of the pre-tests on the computational thinking scale for both the experimental and control groups were at the same level, which meant that the experimental technique could be used in the research. As a result, the groups satisfied the criteria for statistical homogeneity. The fact that there was no significant difference in the overall outcomes of the preservice science teachers' computational thinking abilities before the application began suited the objective in terms of determining whether or not the teaching technique that was used was successful.

In addition, it was seen that the pre-test total mean results of the sub-dimension of the computer thinking scale (CTS) of the preservice science teachers in the experimental and control groups were quite close to each other. Whether the difference between these mean results was statistically significant was examined using independent groups t-test, and no significant difference was found between the groups according to the t value and significance level (p>.05). For this reason, the groups were statistically homogeneous, and at the same time, the pre-test findings of the experimental-control groups regarding the sub-dimensions of the scale of computational thinking were at the same level, which allowed applying the experimental method in the study.

4.1. Findings Regarding the First Sub-Problem in The Study

Table 5 shows the results of the test to see if there was a significant difference between the SLAT scores of the preservice teachers in the experimental group and those in the control group, in which the course was taught according to the teaching method based on interactive simulation (PhET), and the SLAT results of the preservice science teachers in the control group, in which teaching was conducted in accordance with the traditional laboratory processes.

Table 5. t-Test Results for Preservice Science Teachers' SLAT Post-Test Results in Experimental and Control Groups

Measurement	N	$\bar{X}$	Ss	Sd	t	p
Post-Test (Experimental)	30	15.16	2.29	59	4.35	.000
Post-Test (Control)	31	12.61	2.24			

When looking at Table 5, it was clear that the two mean findings were drastically different. The independent groups t-test was used to see if the difference between these mean findings was statistically significant, and the t value and significance level indicated that there was a significant difference between the groups ($t(59)=4.35$; $p<0.05$). This distinction definitely favors the experimental group. This difference benefitted the study's experimental group. When the experimental and control groups' SLAT post-test results were compared, it was determined that the experimental group did better than the control group.

The dependent groups t-test was used to evaluate whether the SLAT findings of the experimental and control groups differed statistically significant. Tables 6 and 7 show the findings of this experiment.

Table 6. t-Test Results Regarding the SLAT Pre-Test-Post-Test Results of the Preservice Science Teachers in the Experimental Group

Measurement	N	$\bar{X}$	Ss	Sd	t	p
Pre-Test (Experimental)	30	7.73	2.86	29	11.02	.000
Post-Test (Experimental)	30	15.50	1.82			

According to Table 6, the two mean results were quite different from each other. As a result of the dependent groups t-test analysis, the t value and significance level ($t(29)=11.02$; $p<0.05$) demonstrated that there was a substantial difference in SLAT outcomes between the experimental group's pre-test and post-test findings. This difference was found to be in favor of the post-test results of the experimental group.

Table 7. t-Test Results of the Pre-Test-Post-Test Results of the Preservice Science Teachers in the Control Group

Measurement	N	$\bar{X}$	Ss	Sd	t	p
Pre-Test (Control)	31	8.06	2.35	30	5.95	.000
Post-Test (Control)	31	12.61	2.24			

According to Table 7 , there was a significant difference between the SLAT pretest and posttest results of the students in the control group ($t(30) = 18.32$, $p<0.05$). When the mean results for the Pretest ($\bar{X}$=8.06) and Posttest ($\bar{X}$==12.61) were examined, it was seen that there was a significant difference between the FKBT results of the students in the control group at the end of the process in which teaching was done in accordance with the laboratory processes. This difference was in favor of the posttest results. In other words, at the end of the process in which teaching was done in accordance with traditional laboratory processes, the students' SLAT results showed a considerable improvement. The reason for this increase might be the fact that the preservice teachers in the control group could make use of the information transferred by teaching in accordance with the laboratory processes used in the teaching of the subject. In lessons taught with these methods, information must be learned and taught. However, when compared with the learning done via teaching based on Interactive Simulation (PhET), it could be stated that according to the Pretest ($\bar{X}$= =7.73) and Posttest ($\bar{X}$ =15.50) results, teaching based on Interactive Simulation (PhET) was more effective than the teaching method suitable for laboratory processes.

4.2. Findings Regarding the Second Sub-Problem in The Study

The results of the test that was used to determine whether or not there was a significant difference after the experimental process are presented in Table 8. The test was designed to compare the Computational Thinking Scale results of the preservice teachers in the experimental group, in which the course was taught via teaching based on interactive simulation (PhET), to the related results of the preservice science teachers in the control group, in which teaching was done in accordance with traditional laboratory methods. The purpose of this comparison was to determine whether or not there was.

Table 8. t-Test Results for CTS Total and Sub-Dimension Post-Test Results of Preservice Science Teachers in the Experimental and Control Groups

Dimensions	Measurement	N	$\bar{X}$	Ss	Sd	t	p
Creativity	Control Group	31	32.74	1.61	59	5.092	.000
	Experimental Group	30	35.40	2.40			
Algorithmic Thinking	Control Group	31	21.03	1.27	59	7.612	.000
	Experimental Group	30	24.20	1.91			
Cooperation	Control Group	31	15.09	3.23	59	3.909	.000
	Experimental Group	30	17.70	1.70			
Critical Thinking	Control Group	31	16.48	1.94	59	3.845	.000
	Experimental Group	30	18.76	2.64			
	Control Group	31	13.90	2.61	59	4.184	.000

Problem Solving	Experimental Group	30	17.13	3.38			
CTS	Control Group	31	104.35	4.89	59	8.005	.000
Total Score	Experimental Group	30	115.33	5.79			

According to Table 8, the preservice science instructors in the experimental and control groups had substantially different CTS post-test total mean scores from each other. In order to determine whether the difference between these mean findings was statistically significant, the independent groups t-test was used, and a significant difference was found between the groups ($t\ (59) = 8.005$; $p < 0.05$). In this case, the experimental group came out on top.

It was also found that preservice science instructors in the experimental and control groups had very different sub-dimension posttest total mean outcomes for the computational thinking ability scale (CTS). Using the t-test for independent groups, we assessed if the difference between these mean values was statistically significant, and we discovered a significant difference between the groups based on the t value and significance level ($p < 0.05$). Table 8 reveals that the experimental group benefited from this difference.

5. Discussion

Similar to the research findings, computer simulations have been shown to improve success in traditional teaching, particularly in laboratory applications (Lin and Atkinson 2011; Rutten et.al, 2012;). It is common knowledge that information that is presented via the use of interactive multimedia formats that are audible and animated (video or animation) is easier to comprehend. This kind of information also helps to offer data that is enjoyable, fascinating, straightforward, and clear. Because the information we get is mostly processed by our senses, notably our ears and sight (Putri & Sofyan, 2020). Likewise, Benaklia, Kostadinov, Satyanarayanab, and Singh (2017) determined that such interactive computer activities in classroom experiences tend to motivate students and actively involve students in the learning process. In their research, Salame and Makki (2021) came to the conclusion that PhET interactive simulations have a beneficial impact on students' attitudes and ideas regarding learning, and that these simulations also assist students in developing their conceptual understanding of chemistry concepts and content. They also help students learn and understand abstract ideas. They also stated that PhET simulations provide learning opportunities that traditional studies do not provide. Contrary to their research findings, Taibu, Mataka, and Shekoyan (2021) concluded in their research that virtual laboratories do not leave a lasting impression compared to physical laboratories, and virtual laboratories are not as fun as physical laboratories. Students' learning results have been improved by incorporating PhET simulation into the classroom (Arabacıoglu & Ünver, 2016; Wicaksono et.al., 2017). Because the cognitive abilities of students of different ages differ, the methods and content criteria of Computer Technology (IT) talent training should also differ. IT research trends and potential research topics are suggested as resources for researchers, educators, and policymakers (Hsu, Chang and Hung, 2018). In the study, it was concluded that at the end of the laboratory course integrated with PheT simulations, the pre-service science teachers' critical thinking skills, which are the sub-dimensions of their computational thinking skills, developed and differed significantly from the students in the experimental group. Similarly, Putranta and Heru Kuswanto (2018) revealed that when PhET learning environments are used effectively in physics learning, they are moderately effective in developing students' critical thinking skills in modeling and application courses. Simulations allow students to work with complex ideas as well as design and build complex systems. Because simulations are flexible and easy to use, students can be encouraged to take more tests in order to critically evaluate their own work (Mvalo & Bates, 2018). At the end of the laboratory course that was integrated with PheT simulations, it was concluded in the study that the creative thinking skills of the pre-service science teachers, which are the sub-dimensions of their computational thinking skills, developed and differed significantly from the students who were in the experimental group. This was in contrast to the findings of the students who were in the experimental group. In a similar vein, Astutik and Prahani (2018) found that the collaborative creativity learning model that is combined with PhET simulation may be utilized as a solution to develop students' creative abilities. In the study, as a result of the application, it was concluded that the algorithmic skills of the pre-service teachers in the experimental group differed significantly compared to the pre-service teachers in the control group and increased. In addition, it was concluded that the collaborative thinking skills, which is the sub-dimension of the computational thinking skills, developed at the end of the laboratory course integrated with the PheT simulations of the pre-service teachers and differed significantly from the students in the experimental group. Studies using computational thinking components show an increase in students' problem solving, abstract thinking, troubleshooting and collaborative learning abilities (Cansu & Kılıçarslan-Cansu, 2019). In the study, it was concluded that the problem-solving skills, which is the sub-dimension of the computational thinking skills, developed at the end of the laboratory course integrated with the PheT simulations of the pre-service science teachers and differed significantly from the students in the experimental group. Similarly, Budiarti, Boy, and Lumbu (2021) stated that students' problem-solving skills can be encouraged with PheT simulations, but PhET simulations do not enable students to acquire alternative concepts and may cause students to experience distraction.

6. Conclusion

It has been concluded that the laboratory application supported by interactive simulation supports pre-service science teachers' learning by internalizing and internalizing the laws of computer thinking and science. The support provided in all sub-dimensions of computational thinking (Creativity, Algorithmic Thinking, Cooperation, critical thinking, problem solving) was found to be significantly effective.

Limitations

Since the sample of the study consisted of pre-service teachers attending the science teaching program of a university located in the Central Anatolian Region of Turkey, the readiness of the pre-service teachers may have affected the results obtained from the study. Therefore, the results are limited to the available sample. At the same time, the research is limited to the determined laws of physics and the science laws achievement test developed by the researchers, which determines the level of learning of these laws.

Recommendation

In teacher education, support can be obtained from interactive simulations in all branches of science education. It can be said that it would be beneficial to use it in experiments that are insufficient, dangerous or that need to be repeated. The use of the developing technology at all levels of education and laboratories where the application is thematic should be expanded.

Acknowledgments

No funding was received.

Conflict of Interest

The authors declare that there is no conflict of interest.

References

Al Musawi, A., Ambusaidi, A., Al-Balushi, S., Al-Sinani, M., & Al-Balushi, K. (2017). Effectiveness of Learning with 3D-Lab on Omani Basic Education Students' Achievement, Attitudes and

Scientific Thinking. *Journal of Education and Training Studies, 5*(11), 177-188. https://doi.org/10.11114/jets.v5i11.2743

Arabacioglu, S. and Unver, A.O. (2016). Supporting inquiry based laboratory practices with mobile learning to enhance students' process skills in science education. *Journal of Baltic Science Education, 15*(2), 216-230. https://doi.org/10.33225/jbse/16.15.216

Astutik, S., & Prahani, B. K. (2018). The Practicality and Effectiveness of Collaborative Creativity Learning (CCL) Model by Using PhET Simulation to Increase Students' Scientific Creativity. International Journal of Instruction, 11(4), 409-424. https://doi.org/10.12973/iji.2018.11426a

Atılgan, H., Kan, A. ve Dogan, N.(2009). *Eğitimde ölçme değerlendirme*. [*Measurement and evaluation in education]*. Ankara: Anı Yayıncılık.

Baek, Y. (2009). Digital simulation in teaching and learning. In Gibson, D. and Baek, Y. (eds), *Digital Simulations for Improving Education: Learning Through Artificial Teaching Environments.* Hershey, PA: IGI Global

Becker, K., & Parker, J.R. (2009). A simulation primer. In Gibson, D. and Baek, Y. (Eds), *Digital Simulations for Improving Education: Learning Through Artificial Teaching Environments*. Hershey, PA: IGI Global

Bell, R. B., & Smetana, L. K. (2008). Using computer simulations to enhance science teaching and learning. *National Science Teachers Association, 3,* 23-32.

Benakli, N., Kostadinov, B., Satyanarayana, A.,& Singh, S. (2017). Introducing computational thinking through hands-on projects using R with applications to calculus, probability and data analysis, *International Journal of Mathematical Education in Science and Technology, 48* (3), 393-427 https://doi.org/10.1080/0020739X.2016.1254296

Benzer, A. I.,& Ünal, S. (2021). Models and modelling in science education in Turkey: A Literature review. *Journal of Baltic Science Education, 20*(3),344-359. https://doi.org/10.33225/jbse/21.20.344

Brooks, G. P., & Johanson, G. A. (2003). Test Analysis Program. *Applied Psychological Measurement, 27,* 305-306. https://doi.org/10.1177/0146621603027004007

Budiarti, I. S, Boy, B.Y., & Lumbu,A. (2021). Students' scientific problem-solving skills in 3T region: using phet simulation to enhance the matter. *Jurnal Pendidikan Fisika dan Keilmuan (JPFK) 7* (2), 59-76. http://doi.org/10.25273/jpfk.v7i2.10783

Büyüköztürk, S. (2007), *Sosyal bilimler için veri analizi el kitabi*. [*Data analysis handbook for social sciences*]. Ankara: Pegem A Yayıncılık

Cansu, F. K., & Kılıçarslan Cansu, S. (2019). An Overview of Computational Thinking. *International Journal of Computer Science Education in Schools*, *3*(1), 17–30. https://doi.org/10.21585/ijcses.v3i1.53

Cela-Ranilla, J.M.& Esteve-González, V. (2015). Using simulation games to improve learniing skills. *Teaching and learning in digital worlds strategies and issues in higher education* (Ed. Gisbert & Bullen) Publicacions Universitat Rovira i VirgiliAv. Catalunya, Tarragona.

Hsu, T., Chang, S., & Hung, Y. (2018). How to learn and how to teach computational thinking: Suggestions based on a review of the literature. *Comput. Educ., 126*, 296-310. https://doi.org/10.1016/j.compedu.2018.07.004

Kalaycı, Ş. (Ed.) (2006). *SPSS uygulamalı çok değişkenli istatistik teknikleri*. [*SPSS applied multivariate statistical techniques*].Ankara: Asil Yayın Dağıtım

Karasar, N. (2004). *Bilimsel araştırma yöntemi*. [*Scientific research method]*. Nobel Yayın Dağıtım. Ankara

Kluge, A. (2007). Experiential learning methods, simulation complexity and their effects on different target groups. *Journal of educational computing research, 36*(3), 27. https://doi.org/10.2190/B48U-7186-2786-542

Korkmaz, O., Cakır, R., & Ozden, M. Y. (2017). A validity and reliability study of the computational thinking scales (CTS). *Computers in Human Behavior, 72*, 558-569. https://doi.org/10.1016/j.chb.2017.01.005

Lin, L., & Atkinson, R. K. (2011). Using animations and visual cueing to support learning of scientific concepts and processes. *Computers & Education, 56*(3), 650–658. https://doi.org/10.1016/j.compedu.2010.10.007

Mvalo, S., & Bates, C. (2018). Students' understanding of computational thinking with a focus on decomposition in building network simulations. In: *CSEDU 2018 Proceedings : 10th International conference on computer supported education*. SCITEPRESS, 245-252

Namdar, B. (2017). Model-based instruction in science teaching. In M. Ergun(Eds.), *New Approaches in Science Teaching*. (pp. 291-313). Ankara: Nobel Akademik Yayıncılık.

OECD (2018). The future of education and skills Education 2030. Retrieved from https://www.oecd.org/education/2030/E2030%20Position%20Paper%20(05.04.2018).pdf

Papadouris, N. &. Constantinou, C.P. (2009) A methodology for integrating computer-based learning tools in science curricula. Journal of Curriculum Studies, 41(4), 521-538, https://doi.org/10.1080/00220270802123946

Palts, T., & Pedaste, M. (2020). A model for developing computational thinking skills. *Informatics Educ., 19*, 113-128. https://doi.org/10.15388/infedu.2020.06

PhET. (2018). Physics Education Technology Project. Available from: https://phet.colorado.edu/tr/

Podolefsky N. S., Perkins K. K., & Adams W. K. (2010). Factors promoting engaged exploration with computer simulations. *Physical Review Special Topics – Physics Education Research*, 6(2), 020117. https://doi.org/10.1103/PhysRevSTPER.6.020117

Potane, J., & Bayeta Jr, R. (2018). Virtual Learning through PhET Interactive Simulation: A Proactive Approach in Improving Students' Academic Achievement in Science. Available at SSRN 3166565.

Prensky, M. (2001). Digital Natives, Digital Immigrants. On the Horizon MCB University Press, 9 (5). Retrieved from https://marcprensky.com/writing/Prensky%20%20Digital%20Natives,%20Digital%20Immigrants%20-%20Part1.pdf

Putranta, H.,& Kuswanto, H. (2018). Improving Students' Critical Thinking Ability Using Problem Based Learning (PBL) Learning Model Based on PhET Simulation. *SAR Journal, 1* (3), 77-87. https://doi.org/10.18421/SAR13-02

Putri,P. & Sofyan, H. (2020). A simulation-based interactive learning multimedia development for photosynthesis and respiration practicum in junior high schools. *Journal of Educational Technology and Online Learning, 3*(3), 311-339. https://doi.org/10.31681/jetol.775947

Rutten, N., van Joolingen, W. R., & Van der Veen, J. T. (2012). The learning effects of computer simulations in science education. *Computers & Education, 58*(1), 136–153. https://doi.org/10.1016/j.compedu.2011.07.017

Salame, I. I., & Makki, J. (2021). Examining the use of PhET simulations on students' attitudes and learning in general chemistry II. Interdisciplinary Journal of Environmental and Science Education, 17(4), e2247. https://doi.org/10.21601/ijese/10966

Strogatz, S. (2007). The end of insight. in brockman, john. what is your dangerous idea? John Brockman (Ed) HarperCollins.

Tabachnick, B. G., & Fidell, L. S. (2013). *Using multivariate statistics* (6th ed.), Boston: Allyn and Bacon.

Taibu, R., Mataka, L., & Shekoyan, V. (2021). Using PhET simulations to improve scientific skills and attitudes of community college students. *International Journal of Education in Mathematics, Science, and Technology (IJEMST),* 9(3), 353-370. https://doi.org/10.46328/ijemst.1214

Wicaksono, I., Wasis, and Madlazim. (2017). The effectiveness of virtual science teaching model (VS-TM) to improve student's scientific creativity and concept mastery on senior high school physics subject. *Journal of Baltic Science Education*, *16*(4), 549- 561

Wieman, C. E., Adams, W. K., Loeblein, P., & Perkins, K. K. (2010). Teaching physics using PhET simulations. *The Physics Teacher,* *48*(4), 225–227. https://phet.colorado.edu/publications/Teaching_physics_using_PhET_TPT.pdf

Wing, J.M. (2008). Computational thinking and thinking about computing. *Philosophical Transactions of the Royal Society of London A: Mathematical, Physical and Engineering Sciences,* 366 (1881), 3717-3725. https://doi.org/10.1098/rsta.2008.0118