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Which is More Effective in Teaching Energy Transformations: Technology-Based or Inquiry-Based Science Teaching?

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Abstract
This research aimed to compare the short and long-term effects of technology-supported and inquiry-based teaching prepared within the scope of energy transformation on students' academic achievement. It was designed as an exploratory action research case study. The research group consisted of forty-three students studying at the seventh grade (between thirteen-fourteen ages) of a public middle school in Turkey during the fall semester of the 2017 year. One of the classes with a similar academic background in the school where the researcher also worked as a science teacher was assigned as the experimental group and the other as the control group. The activities in the experimental group were carried out in a technology-supported manner using PhET simulations supported by also worksheets, while the control group was taught based on inquiry-based hands-on laboratory activities by worksheets. The data were collected through an achievement test consisting of open-ended questions and scoring with a rubric. The test was implemented twice, after the interventions, and in the following sixth month for both groups. Normally distributed data were compared with interdependent and paired-samples t-tests. The results showed that although the achievement scores for the technology-supported teaching group were significantly higher in the post test, no difference between the scores at the end of the sixth months, and significant information losses were experienced in both groups, with the most technology-supported science teaching.
Keywords: Technology-Based Learning, Science Teaching, Energy Transformation, PhET Simulations.

Introduction

The integration of technology into learning and teaching has been facilitated as an expected consequence of the developments in information and communication technologies and the opportunity of easily accessing them (Berrett, et al., 2012; Inan & Lowther, 2010). The technology integration is mainly used to support teaching, rather than to change and improve the teaching environment (Tondeur, et al., 2013). This integration can be achieved in three main ways: preparation for teaching, use of technology for teaching, and use of technology as a learning tool (Inan & Lowther, 2010). In this way, both the goals of the curriculum and the 21st-century skills such as communication, collaboration, critical thinking, and problem-solving, creativity, and innovation can be achieved. These skills are also the 4C goals of physics learning (Mahtari, et al., 2020). The second form of integration - the use of technology for education –has led to more significant outcomes for educators and policymakers. This kind of integration includes processes such as simulations used by teachers and students to participate in research and inquiry processes, and the use of interactive whiteboards (Namdar & Küçük, 2018). In this context, Spector, et al., (2008) describes a simulation as a 'computer-based model of a natural process or phenomenon that reacts to changes in values of input variables by displaying the resulting values of output variables' (p.457).

This integration is an important need for science teaching since it includes many abstract topics and concepts, provides a rich environment, and has special importance.

The integration of technology in science teaching is required since it enable simulations and models in abstract subjects that are difficult to visualize in the mind, to adapt to the learning speed of the student in the virtual use of difficult or impossible areas in the classroom environment, to make teaching enjoyable and powerful, to demonstrate dangerous or impossible experiments in the classroom (Gredler, 2004; Küçük & Bahçekapılı, 2011). The integration of technology has positive results on learning outcomes such as student attitudes (Aslan Efe, et al., 2011; Benli, et al., 2012; Dağdalan & Taş, 2017; Daşdemir & Doymuş, 2014) motivation (Chiang, et al., 2014; Sung, et al., 2017), scientific thinking (Öztürk, et al., 2017), conceptual understanding (Barak & Hussein-Farraj, 2013; Eskrootchi & Oskrochi, 2010; Jaakkola, et al., 2011; Özmen, 2011; Wu, 2010), misconceptions (Küçük & Çalık, 2015; Ramnaraina & Moosaa, 2017; Ozkan & Sezgin-Selcuk, 2015). In addition, it also provides a suitable environment for teaching research and inquiry (Linn & Eylon, 2011; Ma & Nickerson, 2006; Mahtari, et al., 2020). In addition to measurement and evaluation, classroom management and presentation technologies (such as Plickers, Kahoot, Socrative, Quizlet, Beyazpano) that can be used in all courses during the technology integration process, various technological tools such as simulation environments (PhET, Molecular Workbench, NetLogo), augmented reality tools (Animal 3D, Elements 4D), research query environments (APoME, Surge, WISE) can be used for teaching science courses (Mahtari, et al., 2020; Namdar & Küçük, 2018; Haryadi & Pujiastuti, 2020).In particular, the use of pHET simulations improves students' scientific inquiry and scientific process skills in their learning processes based on inquiry (Duman & Avcı, 2016; Haryadi & Pujiastuti, 2020; Uysal & Bostan-Sarıoğlan, 2020; Wieman, et al., 2010). For this purpose, it is possible to prepare and use student worksheets, which are widely used in inquiry-based teaching, during PhET Interactive Simulations (Mahtari, et al., 2020). It is well known that student worksheets make students more active in science learning (Yıldırım, et al., 2014). PhET simulations can also support the development of skills, affective goals, and content learning in an easy, free, and flexible way (Moore, et al., 2014; Wieman, et al., 2010).

Technological tools with a high level of interaction can collect and organize data regarding students' learning processes and provide evidence-based explanations for scientific questions (Sandoval & Reiser, 2004). Modeling, conceptual understanding, and argument-making skills of students learning science in these environments are superior to individual learning (Clark & Sampson, 2007). However, some technological tools do not allow students to interact with the technological tool, while others increase interaction by allowing them to use various variables. Simulations, which increase the interaction with the student and enable computer-aided learning,may be suitable for the constructivist approach (Owusu, et al., 2010). In this sense, PhET is a set of interactive, research-based science and mathematics online simulations (see, https://phet.colorado.edu/) (Correia, et al., 2019; Eveline & Kuswanto, 2019).

The inquiry-based processes, the basic teaching strategy of the science curriculum andfirst implemented in Turkey in 2013, require students to make hands-on laboratory activities, form models, explain and put forward arguments (Ministry of National Education [MNE], 2013). Technology-supported inquiry tools (such as computer simulation) used in science education can also provide an opportunity for students to first-hand experience of knowledge-building by participating in inquiry processes like scientists (Donnelly, et al., 2014; Smetana & Bell, 2012). The content and meta-analysis studies conducted for technology integration indicated a number significant learning outcomes. These studies mostly focused mainly on the effect of digital games on concept learning whereas only a limited number of studies dealt with the scientific processes, affective areas, and socio-contextual learning (Li, 2013). It is now clear that simulation-based learning facilitates learners' conceptual understanding of scientific phenomena (Correia, Koehler, Thompson, & Phye, 2019). Hands-on laboratory activities tend to emphasize design, while virtual laboratory activities emphasize conceptual understanding (Ma & Nickerson, 2006). In this way, students can demonstrate their abilities to apply the active inquiry practices of science by designing investigations, conducting iterative trials, predicting, observing, and explaining findings, and critiquing the investigations of others working on the interactive simulations (Quellmalz, Timms, Silberglitt, & Buckley, 2012).Learners tend to interact with a simulation as a game in the absence of reflection and debriefing (Leemkuil, T de Jong, Hoog, & Christoph, 2003). Therefore, without appropriate tutoring and scaffolding (Duffy & Cunningham, 1996), feedback, and debriefing (Leemkuil, T de Jong, Hoog, & Christoph, 2003), learners do not gain much benefit from the discovery that comes with learning simulations. It is important for an effective inquiry to study a science-related subject with the support of computer simulations and to guide the process and provide feedback through the worksheets. There have been many studies examining the positive effects of different teaching methods supported by computer simulations on learning products (Aslan Efe, Oral, Efe, & Ön, 2011; Ceylan, 2018; Chen & Howard, 2010; Dağdalan & Taş, 2017; Daşdemir & Doymuş, 2014; Dorneles, Veit, & Moreira, 2010; Duman & Avcı, 2016; Güvercin, 2010; Koç Ünal, 2019; Koyunlu Ünlü & Dökme, 2011; Jaakkola & Nurmi, 2008; Jaakkola, Nurmi, & Veermans, 2011; Şimşek, 2017; Teke, 2010; Türkan, 2012). It is also surprising that there are hardly ever any findings regarding negative consequences in technology-supported teaching practices. However, teaching, as described above, has the potential to increase scientific knowledge and process skills, and can provide a positive conceptual change in science.

In experimental studies, the technology integration of some subjects such as force, motion, light and sound, particulate structure and properties of matter, electricity in our life, human and environment, state of matter and heat, solar system and beyond: "space puzzle" and systems in our body were studied. In some of these studies, science teaching based on simulations was compared with other methods. As a result, simulations as a tool for cognitive learning in science was found to play a critical role (Gredler, 2004). As expected, the difference between science classes in which technology integration with simulations was revealed. For an expert educator, technology-based teaching focused on learning may be advantageous compared to conventional teaching where very little effort put on teaching. However, making comparisons between equal intervention programs and discussing the results is more important for the literature. In this context, for an inquiry-based science curriculum, it is an important problem that which are the best tools to support it by taking inquiry into the center. Here, a good comparison can be made between technology-supported science teaching and inquiry-based hands-on laboratory teaching in the classroom. The presentation of supplementary teaching materials (for example worksheets) for students for both groups can validly explain whether the main reason for a possible difference is the teaching style. In this context, this study investigated both intervention's learning outcome on the academic achievement of energy transformation. Energy transformation, also known as energy conversion, is the process of changing energy from one form to another. While it can be transferred or transformed, the total amount of energy that does not change is also called energy conservation. This issue is difficult to understand by middle school students as well as at other learning levels, and often misconceptions are experienced (Küçük, Çepni, & Gökdere, 2005). In this way, test scores measured after the interventions in a short time as well as the retention scores in a long time revealed original results quite different from the literature in terms of learning in science and permanence of it based on technology and inquiry-based teaching.

Method

This research was designed as an exploratory action research case study. It was exploratory because some studies examined the use of technology-based learning and teaching science and focused on some positive learning outcomes. It was action research since it focused on the effect of an intervention academic achievement of energy transformation unit. Further, the researcher, who was also the science teacher of the class, was an active participant in the research the goal of which was to improve science learning through improved teaching. Action research is typically designed and conducted by practitioners who want to improve their practice (Küçük, 2002; Küçük & Çepni, 2005). Since a quantitative action research approach was adopted, the energy transformation achievement test was used to collect data. Two groups of students at the same grade level was included in the study: the experiment and the control group. The topic was selected from the “ Force and Energy “ unit included in the Science Teaching Curriculum of Turkey(Ministry of National Education [MNE], 2013). To examine the effectiveness of the use of technology-based science teaching, the experiment group was taught by science-through-technology-based activities were integrated into the unit. However, in the control group, student-centered and inquiry-based teaching was carried out. The data were collected by using an energy transformation achievement test as post-test and retention test.

Study Group

The study group consisted of 43 students studying at the 7th grade (between 13-14ages) of a public elementary school in Turkey during the fall semester of the 2017 year. The researcher, as explained before, taught both groups as the official science teacher of the school. Since the researcher knew that both groups’ academic achievement in science was equal, the groups were randomly assigned as the experiment and the control group. There were 22 students (14 males and eight females) in the experiment and twenty-one students (13males and 8 females) in the control group.

The Technology-based Science Teaching

The Force and Energy unit is included in the Physical Events learning area of the 7th-grade science curriculum in Turkey (MNE, 2013). In this unit, students are expected to learn the concepts of mass and weight and to comprehend the relationships and differences between them, to be aware of the existence of gravity between celestial bodies due to gravity, to describe the work done in physical terms, to express the factors affecting work and the unit of work, to realize the relationship between force-work and energy. It is also aimed to classify their types, to observe the effect of friction force on energy, to make designs for the effects of air and water resistance, and to gain knowledge and skills. The unit consists of three sub-topics: Mass and Weight Relationship, Force, Work, and Energy Relations, and Energy Conversions. In the program, six hours are allocated for the first two topics and eight hours for the last topic. The concepts of the last topic are conservation of energy, loss of kinetic energy by friction, air and water resistance. In this regard, students are expected to achieve three gains: (i) the conversion of kinetic and potential energy types to each other, (ii) describe the effect of friction force on kinetic energy, and (iii) design a tool to reduce the effect of air or water resistance.

The current research was designed for Energy Transformation. The technology-based teaching material was a two-week event, four hours a week, and a total of eight hours designed by the researcher. The treatment group received inquiry-based science instruction integrated with PhET simulations, and the control group received inquiry-based hands-on laboratory science instruction. The researcher had been teaching science for 16 years and considered herself to be a “hands-on teacher” and believed that students learn by doing better than by bookwork. These activities were taught by the researcher. The researcher experienced teaching science at the elementary school levels and was also familiar with the techniques and the strategies of technology. The researcher already taught science through technology to several classes at the elementary levels before conducting this study and completed a course called “technology-assisted science education” in postgraduate education.

In this process, four worksheets in Predict-Observe-Explain (POE) format were prepared for both groups. The activities were carried out by using these worksheets based on the two lesson plans. In the first part of the lesson plan in which the first worksheet was used, the following teaching was performed respectively for the experimental group:

1. Energy skate park simulation on the pHET (see, https://phet.colorado.edu/en/simulation/legacy/energy-skate-park) was opened by the teacher on the interactive board.
2. The slide dropped from different heights and movements were observed.

3. Observations were recorded on worksheets and shared by some of the students.
4. Teacher clicked on the "GRID" section on the right. Students were asked to predict and record what the skateboarder would move when it was released from the numbers 2, 4, and 6 in sequence. While recording their predictions, they were reminded to mention the speed and the highest possible point by the teacher.
5. After the predictions were read by some of the students, the movement was observed and the observations were recorded on the worksheet. Observations were shared by several students. And the feedback was given to the classroom by the teacher.
6. Based on their observations, they were asked to explain the skateboarder's movement in detail with the concepts of potential energy, kinetic energy, and altitude. The explanations were firstly recorded and then read, and feedback was given to the class by the teacher.

In the second part of the lesson plan in which the second worksheet was used, some graphics were drawn by performing the following teaching:

1. The students were asked to first estimate the potential energy, kinetic energy, and total energy states and show their predictions by drawing a column graph before the skateboarder came to points 2, 4, and 6 respectively, and started his movement.
2. After the drawings were made, some of them were examined in front of the class.
3. The skateboarder was brought to point 2, 4, and 6, and the graphs drawn by the simulation were examined (At first, they were asked to examine the potential energy, kinetic energy, and total energy states). After this observation, the students were asked to draw graphics again.
4. After the skateboarder was released from numbers 2, 4, and 6 respectively, they were asked how the energy changes were during the movement. They were asked to explain their predictions in detail (They were reminded to explain using the concepts of potential energy, kinetic energy, and total energy)
5. After some of these predictions were shared by the students, they were asked to watch the simulation and chart what they observed. Feedback was given after some of the graphs were reviewed by the class.
6. Based on their observations, they were asked to explain kinetic energy, potential energy, and total energy transformations.
7. It was ensured that a few of the explanations were shared and feedback was given.

For the second lesson plan, the playground was selected to investigate the effect of friction force. A low inclined plane was prepared with a maximum height of 2. Only the grid box was selected in the right side menu. Two worksheets 3 and 4 were used for this plan. In question 1 in worksheet 3, it was emphasized that the skateboarder should move at a certain speed. The goal was that they could associate movement with friction force, not height. Therefore, height emphasis was not made. In the simulation used, it was necessary to leave the skateboarder on a slope to give it the first move. After the estimates on the worksheet were filled in, the students were directed to leave the slope to speed up with the questions asked.

In this way, the teaching was carried out according to worksheets 3 and 4. Firstly, they were asked to write on the worksheet what can be observed about the movement of the skater after a certain speed and the changes observed in the movement of the skater compared to the first state after a while. After some of these predictions were shared with the class, they were enabled to record their data by making relevant observations. Finally, using the observations (data) of the first two stages of the skate boarder's movement, they were asked to explain the effect that caused the changes in movement.

Starting from the explanation section of worksheet 3, it was shared that the effect of moving objects and the skateboard to stop was the "force of friction". In this context, first of all, the questions "how does the friction force affect the kinetic energy of the object, and is there a relationship between the mass of the object in motion and the distance it will stop? were asked. Again, predictions about these questions were recorded, shared with the class, and then observations were made. Finally, using the observations (data), they were asked to explain the relationship between motion and the mass of the object and the force of friction. In the following questions of worksheet 4, it was asked to study the relationship between the distance the object in motion will stop and the type of the surface. Referring to these studies,it was explained that the object had potential energy since it was initially left from the height, when the motion started and the height of the object decreased, the potential energy transformed into kinetic energy, and after a while, the kinetic energy ended because the object stopped. In this context, the students were asked that the consumed energy might transformed. Explanations made on this subject were shared with the class. Finally, they were asked to give examples of daily life energy transformations.

The students in the control group, on the other hand, completed all the activities in the other plan, except for PhET simulations (see, https://phet.colorado.edu) about energy transformation. In addition, students were encouraged to conduct inquiry-based hands-on laboratory activities in their groups. In this group, all activities were taught using worksheets based on the predict-observe-explanation method. In the first activity in which potential energy was processed, students dropped objects of different magnitudes into the sandbox from certain heights and examined their tracks. After, they continued investigations on the inclined ramp set up in the laboratory for kinetic energy changes depending on the speed and mass. In the worksheets prepared for each activity, they were asked to firstly make a prediction, then make observations by doing the experimental study and record the data, and finally explain the relationship between the predictions and their observations. In this way, they were allowed to draw graphs of energy change on the worksheets for each activity. In addition, they were asked to rub the eraser on the table in the classroom for friction and they were made to notice the heat generated during friction. Immediately after, they made an experimental design to observe the relationship between mass and velocity in different inclinations and inclined planes covered with different materials. In this way, after observing and recording the experimental data, they announced it. Potential and kinetic energy graphs were also drawn for this experimental activity. Finally, going out of school with the students, a ball rolling activity was held on a ramp. In this activity, the velocities of different masses on the ramp were measured, discussed and graphics were drawn. In this way, the teaching process in both groups was completed in a total of eight hours.

Data Collection

The data were collected based upon an energy transformation achievement test both as a post-test and retention test. This test included eight questions, each associated with the three achievements of the subject in the program. In this test, there were questions with visual support for establishing the relationship between the problems encountered in daily life and energy transformation, drawing energy transformation graphics, and interpreting conceptual cartoons about events. As an example, the sixth question in the test is given below.

Question: When the recess bell rings, Emre runs rapidly towards the stairs and suddenly begins to fall down the upper step. Please write in detail your views on what is said below about Emre's fall.

The wet ladder has slipped because it reduces friction.	When wearing a shoe with a smooth bottom, the friction increases and does not slip.	If the floor is made of a rougher material, the friction will be high and the feet will not slip.
Tuna	**Suna**	**Luna**

Tuna says TRUE / WRONG

Because…..

Suna says TRUE / WRONG

Because………......................................

Luna says TRUE / WRONG

Because….…...

Figure 1 Sample Question in the Test

In addition, the rubric for scoring the related question is given as an example below.

For points	If a student,
3	Logically explains the whole relationship between wet and rough-smooth ground and friction and falling.
2	Logically explains the relationship between wet and rough ground and friction and falling.
1	Logically explains the relationship between wet ground and friction and falling.
0	Does not provide a logical explanation for the relationship between wet and rough-smooth ground and friction and falling.

The validity of the test was also checked by an expert in science education. The test was administered to the students in both groups twice as a retention test at the end of the sixth month following the application of the post-test. The pilot application of the test was carried out with another 7th-grade student the researcher taught. In this way, the item analysis of the questions was made and it was found that the item difficulties varied between 0,35 and 0,61 and their discrimination ranged from 0,21-0,45 by Nitko (2004) formulas. The semi-test reliability of the test was found 0,73.

Data Analyses

A rubric ranging from 0-3 was prepared for scoring each question in the energy transformation achievement test. In this way, it was aimed to ensure scoring reliability. Studies on scoring success with open-ended questions and analyzing them with rubric can be found in the literature (Küçük, 2020; Küçük & Yıldırım, 2021). In the preparation of this key, support was also received from experts in the field of science education. First, 10 papers scored by the researcher in the pilot study were randomly selected and asked to be scored by the other expert. In this way, the correlation coefficient between both scorings was calculated as 0,87. This result indicated that the researcher made reliable scoring using the prepared rubric. After this situation was confirmed, all papers in both study groups were scored by the researcher. In the comparison of the obtained scores, the paired-samples and independent t-test , as the parametric tests was performed as a result of the normality test (Büyüköztürk, 2012). The level of significance for each comparison was accepted as .05.

Results

Normality tests were conducted before comparing achievement test scores in both experiment and control groups. Normality test results are given in Table 1.

Table 1 Kolmogorov-Smirnov Test Results

Values		Experiment post	Experiment_ retention	Control post	Control_ retention
N		22	23	21	16
Parameters	$\bar{x}$	29,409	20,826	24,190	19,375
	S	5,095	8,043	7,00	8,188
K-Smirnov Z		,168	,133	,108	,191
p		,108	,200	,200	,120

As shown in Table 1, Kolmogorov-Smirnov test revealed that there was not a significant difference in test results anf the data had a normal distribution. Therefore, paired-samples and also independent samples t-tests, two of the parametric tests, were conducted to compare the ET test scores of the experimental and control groups.

Table 2 shows the independent samples t-test results for the ET post-test scores of the experimental and control groups.

Table 2 Independent Samples t-test Results for ET Post-Test Scores

Point	Groups	N	x̄	S	t-Test		
					t	Sd	p
Energy Transformation Test	Experiment post	22	29,409	5,095	2,803	41	,008
	Control post	21	24,190	7,004			

Table 2 indicated that the ET test scores of the experimental group in which technology-supported science teaching was applied, differed statistically from the control group in which the inquiry-based teaching was applied at the significance level of .05 (t=2,803; p<.05). Although control group had an average of 24,190 points, the experimental group achieved 29,409 points. This revealed that the experimental group was significantly more sucssessful.

In addition, the results of there tention test applied six months after the experiment were compared using an independent samples t-test. The results are shown in Table 3.

Table 3 Independent Samples t-test Analysis Results for ET Retention Test

Point	Groups	N	x̄	S	t-test		
					t	Sd	p
Energy Transformation Test	Experiment_ retention	22	21,500	7,538	,827	37	,413
	Control_ retention	16	19,375	8,188			

As seen in Table 3, there was no difference between the retention test scores(t=,827; p>.05). There was a decrease in the average scores in both groups and the most decrease was observed in the experimental group. There was an average decrease of 5 points in the control group and 8 points in the experimental group. In this context, the post and retention scores for both groups were compared using the paired-samples t-test. The results are shown in Table 4.

Table 4 Paired-Samples T-Test Results for ET Post and Retention Test Scores of Control and Experimental Groups

Test	Points	N	x̄	S	t-test		
					t	Sd	p
Energy Transformation Test	Experiment post	22	29,409	5,095	-6,041	21	,000
	Experiment_ retention		21,454	7,632			
	Control_ post	16	25,375	6,721	-2,795	15	,014
	Control_ retention		19,375	8,188			

As shown Table 4, there were both statistically significant differences between the post and retention scores of the control (t=-2,795; p<.05). and experimental groups (t=-6,041; p<.05). In other words, there was a significant decrease in the ET test scores of both the technology-supported and also inquiry-based science teaching.

Discussion

There is a still ongoing debate on how to achieve learning in general and science learning in particular. For now, it is sufficient for students to acquire these competencies in the context of scientific literacy and therefore 21st-century skills (Fadel & Trilling, 2009). On the other hand, the issue which approaches and methods can best achieve success is among the primary problems of both education researchers and policymakers. Obviously, at this point, success is driven by the theoretical perspective of the stakeholders towards learning (Küçük & Küçük, 2018). As an example, a theoretical approach to constructivist learning requires students to be active producers of knowledge, rather than passive information receivers in the science learning environment (Özmen, 2004; Yıldırım, Küçük, & Ayas, 2014). This can be achieved by actively participating in the learning process, cognitively and affectively, and taking first-hand responsibility in the learning process. The process also requires that learners transform into primary producers rather than simply consumers of knowledge. The way to do this is to provide learners with innovative methods by which they can follow the experiences and questioning processes experienced by scientists in the process of building scientific knowledge. For these reasons, inquiry-based methods have been used as an effective tool in science teaching for many years. This method, which was initially constructed with experiments in laboratories, has evolved into another dimension with the integration of innovations in information and communication technologies into education. However, although there is consensus on the fact that hands-on laboratory activities support investigative science learning, there is still debate on how to produce more effective results (Uysal & Bostan-Sarıoğlan, 2020). The issue of whether the learners who personally carry out hands-on activities in the science laboratory or the learners who make the integration of appropriate technologies through their simulations can produce better learning products emerges as an important problem. Examining the reflections of inquiry-based science teaching on students' conceptual learning and thus their academic achievement, which is among the learning products that are accepted as an important indicator of this, in a short and reasonable time may be a solution to the problem.

For these reasons, in the present study, two contexts - technology integration and hands-on laboratory experiments -based on the examination of energy transformations, which are quite difficult to learn and an abstract subject (Küçük, Çepni, & Gökdere, 2005) were compared by a teacher-researcher who thought that learners should build their knowledge in the learning environment. The effect of interventions, one of which was PhET simulations and the other was hands-on laboratory experiments, prepared for two groups explained in the method section, on the learning products was measured twice through a post test after the intervention and a retention test administered approximately six months after the intervention. Surprisingly, all cognitive and affective learning outcomes were reported positively in science classes with technology integration on a theoretical basis, and there was also limited work on the permanence of learning products (Dikmen & Tuncer, 2018; Dinçer & Güçlü, 2013; Namdar & Küçük, 2018). It was believed that inquiry teaching based on well-managed hands-on laboratory experiments in which worksheets were also used could produce similar outcomes. There was no need for a re-test since both classes were officially confronted with the subject of energy transformation in the science curriculum and their learning in other science subjects was equivalent. At the end of the eight hours planned for both interventions, it was deemed sufficient to perform the post test and the retention test six months later. In this context, the average achievement points of the students in the experimental group, which was integrated with technology with simulations, were slightly higher than the group in which hands-on laboratory experiments were performed. The result of the independent samples t-test conducted to test whether this difference was statistically significant showed that the difference was significant in favor of the experimental group (see Table 2). This result was interpreted as that technology integration increased the achievement in science more than the other inquiry-based learning in the short period. This result was also supported by studies comparing the effects of virtual and traditional laboratory applications on success in science teaching (Çinici, Özden, Akgün, Ekici, & Yalçın, 2013; Duman & Avcı, 2016). The student worksheets with PhET simulation prepared using the predict-observe-explain method were effective in improving student learning outcomes as supported by some studies (Mahtari, Wati, Hartini, Misbah, & Dewantara, 2020). On the other hand, it was found that the retention scores of both groups decreased at the end of the six month (see table 3). However, the difference was not significant. In addition, the paired-samples test scores between the post and permanence test scores of both groups were found to be significant (see Table 4). In other words, there was a level of loss in the learning of both groups that can be considered statistically significant. This result revealed that technology-based science teaching in a short time at least showed a difference when compared to hands-on laboratory-based science teaching in the transformation of the energy studied, but this difference was not preserved in a long time. There is some research supporting this result in the literature (Şimşek, 2017). Now, at this point, the main conclusion drawn in the current study is that multi-stimulus and interactive tools such as simulations in science teaching where technology integration is made attract students' attention and this probably affects learning outcomes that are not adequately transferred to long-term memory. Some studies have already been conducted to show that there is no significant difference between the effect of laboratory-assisted physics education on student achievement and the effect of computer-supported (simulation) instruction on student achievement (Bayrak, et al., 2007). Therefore, it is recommended to study new alternative ways in which the two will work together, instead of a method that relies solely on technology integration and neglects hands-on laboratory experiments in which information can be functionally stored in long-term memory. Nowadays, studies have started to experience this initiative (Uysal & Bostan-Sarıoğlan, 2020).

Conclusion

Technology-based science teaching, which exhibits higher learning outcomes compared to teacher-centered and presentation-based teaching, cannot stand out enough when it is compared with inquiry-based science teaching by hands-on laboratory experiments. In this process, student worksheets with PhET simulation and based on predict-observe-explain method improved student learning outcomes. This method enabled students to test their knowledge in a computer environment, as well as the teacher to provide feedback and corrections instantly. In case of the fact that the science subject is abstract and laboratory facilities are not sufficient, technology-based inquiry teaching may be preferred as economic output, but it is very necessary to insist on hands-on laboratory experiments in environments where the conditions are suitable.

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