ORIGINAL ARTICLE

Technology-Based or Hands-On in Learning of the Concept of Pressure

Hakan Türkmen, Şahsenem Öz

Ege University, Izmir, Türkiye

***Abstract**: The aim of this study is to determine the effects of simulation and a real lab experiment on the academic achievement of 8th grade students on the subject of Pressure in the Science lesson by using the learning cycle model and to determine student opinions about the interventions. In this study, a mixed research model, that combines both qualitative and quantitative methods, was implemented to ensure a comprehensive analysis of the research problem. A pre-test post-test control group experimental study was used in the quantitative part of the study, while a structured interview form was used in the qualitative part. One experimental group (N=48) and one control group (N=44) participated in this study. During the exploration phase of the learning cycle model, the experimental group utilized simulations, while the control group conducted a physical laboratory experiment. The academic achievement test, consisting of 20 multiple-choice questions, was administered at the beginning and end of the lesson. Its average difficulty is 0.711, the discrimination index is 0.404, and the KR-20 internal consistency coefficient is 0.73. The interview questions consisted of 3 open-ended questions. According to the findings, students who explore simulation techniques show a greater increase in academic achievement than those who engage in real lab experiments.*

Science Insights Education Frontiers 2025; 28(1):4577-4597
DOI: 10.15354/sief.25.or765

How to Cite: Türkmen, H., & Öz, S. (2025). Technology-based or hands-on in learning of the concept of pressure. Science Insights Education Frontiers, 28(1):4577-4597.

***Keywords**: Technology-Based Learning, Simulation Experiment, Hands-On Experiment, Laboratory Experiment*

***About the Authors**: Hakan Türkmen, Prof. Dr., Department of Mathematics and Science Education, Science Education, Faculty of Education, Ege University, Türkiye. E-mail: hakan.turkmen@ege.edu.tr, ORCID: https://orcid.org/0000-0003-4572-7062*

Şahsenem Öz, Department of Mathematics and Science Education, Science Education, Institute of Educational Sciences, Ege University, Türkiye. E-mail: ozsahsenem1@gmail.com , ORCID: https://orcid.org/0000-0003-4130-4687

***Correspondence to**: Hakan Türkmen at Ege University in Türkiye.*

***Conflict of Interests**: None*

***Funding**: No funding sources declared.*

***AI Declaration**: The authors affirm that artificial intelligence did not contribute to the process of preparing the work.*

Introduction

THE CONCEPTS of science are generally understood as abstract and intricate. Due to this, students have many misconceptions about science (Bayrak et al., 2007; Mnguni, 2014), especially physics-related concepts. As a case in point, a study examining common misunderstandings in science education discovered that 33 pertained to physics, 12 to chemistry, and 15 to biology (Soeharto et al., 2019). Therefore, how conceptual change can be provided is a salient issue for science education, and the general method for this is hands-on experience.

As Nersessian (1989) expressed, "Hands-on experience is at the heart of science learning." (p. 179). Laboratory experiments are one of the most well-known practices for understanding of the natural world by welcoming students' tangible experiences with objects (Hofstein, 2017; Hofstein & Lunetta, 1982) and making students realize their misunderstandings while conducting experiments (Nersessian, 1989). According to Hofstein (2004), experimental practices are important for learning. During the experimental process, students were able to actively participate in the scientific process by controlling instruments and observing the results (Ratamun & Osman, 2018). These hands-on activities provided by experiments increase students' attitudes toward science (Karpudewan & Meng, 2017), facilitate learning (Kırılmazkaya & Dal, 2022), provide memorable learning (Tsai, 1999; Ünal & Aral, 2014).

Additionally, by conducting science experiments, students can develop various skills, such as creative thinking, higher-order thinking, problem-solving, and scientific skills (Eren et al., 2015). Some studies have shown that laboratory activities increase students' creativity (Lee & Park, 2021; Panjaitan et al., 2019). Moreover, improvements in scientific skills are a significant outcome of laboratory activities. Raghubir (1979) discovered that students who conduct laboratory practices set higher-level cognitive abilities such as constructing assumptions, designing-executing investigations, and developing hypotheses. Furthermore, experiment-based instruction can improve students' problem-solving skills (Ünal & Aral, 2014; Zuhaida, 2018). Ünal and Aral (2014) compare students who received experiment-based instruction and those who did not. It was found that students who learned with experiments displayed enhancement in problem-solving skills and more permanent learning.

In addition to cognitive outcomes, there are multiple affective domains that experiments provide. Attitudes and interests have often been listed as affective domains (Hofstein & Lunetta, 1982). Karpudewan and Meng (2017) found that experiment-based instruction resulted in a more favorable attitude toward science learning when compared to traditional classroom-based instruction. Similarly, Kırılmazkaya and Dal (2022) indicated that hands-on science activities, even those using simple tools, are beneficial for creating positive science attitudes among students. Increasing students' attitudes toward science through experiments is significant, as it can help foster their higher-order thinking skills during the process (Karpudewan & Meng, 2017). Curiosity is also an essential affective outcome of experiments (Coxon, 2012). According to Lee and Erdogan (2007), experiments can fortify students' curiosity as they provide greater freedom to use their creativity. Moreover, experiments can improve social abilities since these activities require cooperative teamwork, social interactions, and democracy (Hofstein & Lunetta, 1982; Salame & Makki, 2021).

Although hands-on experiments abound in their benefits, some limitations still exist. Financial costs, safety issues, measurement errors, potential equipment malfunctions, a lack of laboratories at schools, and inadequate laboratory resources are the main limitations of traditional experiments (Ambusaidi et al., 2018; Salame & Makki, 2021; Tüysüz, 2010). To minimize these limitations, the virtual alternatives of the experiments were considered. Additionally, as innovative technologies emerge and younger generations are surrounded by various digital devices, conventional activities are naturally being replaced by virtual alternatives. Experiments were superseded with simulations, computer-supported web sources, mobile applications, and augmented/virtual reality activities. One explanation for this change is that today's students are exposed to various technologies in their daily lives and expect such materials to be incorporated into their classes (Couch, 2014). One of these technologies is simulation, which is a commonly recognized and easily accessible technology that is frequently integrated into classrooms.

Simulation is defined as computerized models that can facilitate concept learning with scaffolded models of real-world facts through demonstration and interactive learning (Bell & Smetana, 2008). Computer simulations were first used in meteorology and nuclear physics in the late 1940s and have become indispensable in an increasing number of disciplines. It has become widespread because of its usability, affordability, and flexibility (Bakaç et al., 2011; Blake & Scanlon, 2007). Computer simulations are generally used for three purposes: (1) for heuristic purposes, they are used to predict data that we do not have or to build an understanding of data that we already have. Computer simulations can be used in classroom settings to help students visualize hidden structures in phenomena and processes that are impractical, impossible, or costly to demonstrate in a laboratory setting; (2) for predictive purposes, to reconstruct the future or the past; and (3) to understand systems and their behavior, to answer questions about how events might have occurred or how these events actually occurred in light of data showing how the system behaves. Computer simulations in education are known as virtual experiments. During COVID-19 times, teachers could not make students conduct experiments; instead, simulations supported the content and delivered a resolution to distance learning (Joao & Clara, 2007). Virtual experiments are rich resources as they offer easy-to-use experiences via images, graphics, and illustrations, making the learning process more concrete and coherent (Ambusaidi, 2018; Gibbins & Perkin, 2013; Tüysüz, 2010). The scaffolding provided by simulations is effective in working on complex situations and topics (Chernikova et al., 2020; Oghlu Sharifov, 2020). Additionally, simulations have a positive effect on academic achievement (Bakaç et al., 2011), motivation, attitudes, self-efficacy (Dyrberg et al., 2017; Salame & Makki, 2021; Tüysüz, 2010), scientific thinking (Ambusadi et al., 2018), and critical thinking (Oghlu Sharifov, 2020).

The purpose of simulations is to provide inquiry-based virtual laboratory experiments with animations and interactive activities (Salame & Makki, 2021). These simulations can foster students' comprehension through demonstrations, animations, and interactive content (Erlin Eveline et al., 2019; Makransky et al., 2017). However, as experiments, simulations also have some drawbacks. While traditional experiments improve handling skills, such as constructing an experiment or using lab equipment, simulations do not offer the same opportunities (Gibbons et al., 2004; Hawkins & Phelps, 2013).

Research has been conducted on the effectiveness of simulation techniques versus real lab experiments in students learning to understand both methods profoundly. However, the results are controversial, which indicates the need for further studies on this topic. While some studies have found results favoring real lab experiments or simulations technique (Chang et al., 2008; Bakaç et al., 2011; Chernikova et al., 2020; Hensen et al., 2020; Husnaini & Chen, 2019; Ratamun & Osman, 2018; Saiftri et al., 2020; Tüysüz, 2010; Wang & Tseng, 2018), other studies have found no significant differences between the two methods (Ambusadi et al., 2018; Kerr et al., 2004; Ma & Nickerson, 2006; Nanto et al., 2022; Putri et al., 2019).

Such comparisons have generally been made using traditional teaching models. A study using a student-centered model such as the learning cycle could not be found. The learning cycle is a model for learning that was first proposed by American Robert Kalplus and his colleagues in the early 1960s. It is based on Piaget's theory of mental development. The learning cycle consisted of three phases: exploration, term/concept introduction and concept application.

Exploration: The teacher presents a problem situation that gives students the opportunity to conduct research; provides students with materials and opportunities to collect data; helps them to use scientific process skills; also keeps the students interested in the topic and manages their behavior; observes the students while they work, gives direction (guidance) to their questions. An attempt was made to remove the science concept from the activity, and no direct information was given in the first stage of the learning cycle.

Term Introduction: This phase is used to gather students' previous experiences and to build a set of concepts or generalizations. Students analyzed the data obtained. Under the guidance of the teacher, students report, analyze, and articulate their experiences or data to the class. At the end of the phase, the teacher ends by providing terminology or defining/summarizing. The teacher guides the students through this process, but should allow them to verbalize the data and terms so that the students can learn the concept in a meaningful way.

Concept Application: It is the stage where students reinforce the knowledge and concepts they have learned by applying them to new and different situations. It is generally used to adapt to daily life conditions. The students were asked questions about different situations. This stage is especially useful for students whose level of mental development is below average and who therefore cannot associate their own experiences with what the teacher tells them; they have difficulties in realizing meaningful learning. New knowledge becomes more useful when applied to new situations. Other (additional) cases involving the same concept have been discussed and/or analyzed. It is measured whether the children had learned the concept.

However, studies comparing real lab experiments and simulation techniques mostly use quantitative methods, which are beneficial for obtaining empirical results. However, qualitative data must be supported to understand why a particular method is beneficial. Therefore, this study to compare laboratory experiments and simulation techniques on the academic achievement of 8th grade students in the Science lesson on the subject of pressure and to examine student opinions about the science course taught with simulation technique with a mixed method design. In addition, this study addresses the knowledge gap regarding the advantages of simulation techniques or laboratory experiments in middle school science courses by supporting it with both quantitative and qualitative data. For this purpose, two questions were posed.

- *Is there a difference in the academic achievement of the experimental group (simulation) and the control group (laboratory experiment) in the science lessons?*
- *What are the students' opinions about the science course taught through simulations and real lab experiments?*

Table 1. Research Design.

Group	Pre-test	Intervention – 8 hours (2 weeks)	Post-test
Experiment	Academic Achievement Test	Exploration phase of Learning Cycle model: Simulation technique	Academic Achievement Test + Interview form
Control	Academic Achievement Test	Exploration phase of Learning Cycle model Lab. Experiment technique	Academic Achievement Test + Interview form

Methods

In this study, a sequential explanatory design, one of the mixed method research designs, was used. In this design, quantitative data were first collected and analyzed. Qualitative data were then collected and analyzed. Finally, whether qualitative data support quantitative data and their relationships with each other is revealed (Baki & Gökçek, 2012). To compare the effect of learning the pressure unit with simulation and lab experiments on students' academic achievement, a quasi-experimental study with pre-test and post-test control groups was conducted, and student opinions about the lessons taught with simulation and lab experiments were collected as qualitative data.

Study Group

The population of the study consisted of 8th grade students studying in the central district of a metropolitan city. While the school was selected according to purposive sampling, it is one of the 5 schools in the academic achievement ranking of secondary schools in the central district (a ranking made by the Ministry of National Education) and has the highest student population. Among the 6 8th grade classes in the school, 2 classes were randomly selected as the experimental group (n = 48 students) and 2 classes as the control group (n = 44 students). These groups had no experience of using simulation techniques in science lessons (**Table 1**).

Data Collection Tools

An academic achievement test and a structured interview form were utilized. These tools gathered student opinions about the course, which employed the simulation technique for the experimental group and the lab experiment for the control group in the exploration step of the learning cycle teaching model.

The Academic Achievement

Özcan, Koca, and Söğüt (2019) used an academic achievement test consisting of 20 questions for the "Pressure" unit. An expert opinion was taken for the validity of the test, a pilot study was conducted, and the KR-20 internal consistency coefficient was found to be 0.73. The 20-item achievement test was considered reliable and valid. The item difficulty index of the prepared questions was 0.711 and the item discrimination index was 0.404. It can be observed that the questions applied to the students were discriminative. The discrimination index of all questions was greater than 0.25 and the items were successful in distinguishing between students who knew and those who did not know.

Interview form

In the study, a "structured interview form" was used to obtain the opinions of 8th grade students about the lessons taught with the simulation technique and lab experiment. This form consisted of three open-ended questions. The questions are as follows:

- What are the positive aspects of simulation/experiment application? Explain.
- What are the negative aspects of simulation/experiment application? Explain.
- Comparing the simulation and experimental applications, if you had to choose between the two, which one would you choose? (only for the experimental group students)

Process

The academic achievement test consisting of 20 multiple-choice questions was administered as a pre-test to the experimental and control groups for 40 minutes before the lesson plans taught with the learning cycle model; At the end of the lesson, the same academic achievement test was used as a post-test and students' thoughts were collected through interview questions.

The lessons took 8 hours in 2 weeks. During the lessons using the learning cycle learning model, 3 different concepts, solid, liquid, and air pressure, were taught. The exploration and concept application phases of each concept took an average of 1 hour. In the remaining 8 hours, the term introduction phase lasted. Simulation applications use websites that offer free simulation services, such as phet, javalab, and formative.

The academic achievement was then repeated at the end of the lesson. Thereafter, a structured interview form was given to the experimental and control group students, and they were asked their opinions about the science lessons taught by simulation and experimentation based on their experiences (**Table 2**).

Table 2. The Process of Learning Cycle Model Lesson Plan.

Learning Cycle	Experiment group	Control group
Exploration phase (3 hours)	Experimental group students were divided into groups, and simulation applications related to “Solid Pressure” (1 hour), “Liquid Pressure” (1 hour), and “Open-Air Pressure” (1 hour) were used on the smart board.	They were asked to perform laboratory experiments related to pressure as *Solid Pressure (sponge brick experiment, bed of nails experiment, truck/cars driven on the sand experiment) (1 hour), *Liquid Pressure (liquid filled plastic bottle drilling experiment, dipping balls into containers of different fullness experiment)” (1 hour), * Open Air Pressure (experiment of putting an egg in a hot bottle experiment, experiment of closing a bottle over a candle in a container of water experiment) (1 hour).
Term Introduction phase (2 hours)	For both groups, the answers they obtained as a result of the research conducted in the exploration step were talked to each other and discussed. Later, they were asked to define the variables affecting solid, liquid, and open-air pressure.	
Concept Application phase (3 hours)	For both groups, examples of the place of scientific knowledge in daily life and mutual exchange of views were made. 3 case study scenarios about solid, liquid and open-air pressures. Afterwards, the concept cartoons, concept maps, and matching questions techniques were applied	

Analyzing Data

The SPSS-22 program was used for statistical calculations of the quantitative data obtained from the achievement test. The scores of students in the experimental group, who used the simulation technique during the exploration step of the Learning Cycle model, were compared with the scores of students in the control group, who participated in a traditional lab experiment. In the literature, it is recommended to use Shapiro-Wilk Test if the sample size is less than 50 and Kolmogorov-Smirnov Test if the sample size is larger than 50 (Razali & Wah, 2011). Some sources state this figure as 30 (Mayers, 2013). Since our pre-sample groups were 44 and 48, we wanted to be sure using both tests. According to the results we obtained, Sig: 0.486 for the Shapiro-Wilk Test and Sig: 0.235 for the Kolmogorov-Smirnov Test, that is, our data shows a normal distribution since it is bigger than 0.05. As both groups demonstrated a normal distribution of scores, an independent sample t-test was conducted to compare their achievements. A dependent (paired) sample t-test was used to compare the mean scores of the pre-test and post-test achievement tests of the groups. In addition, the Levene test, which is a hypothesis test to evaluate the equality of variances for a variable calculated for two or more groups, was also applied. Descriptive analysis was then used to analyze the answers given to the interview form applied to the experimental and control group students, enabling the collection and analysis of students’ opinions about the applied course. In qualitative research, coding symbolically assigning words or short sentences to research data in line with the research objectives. As soon as the data were collected

Table 3. Comparison of Pre-Test Scores of Students in Experimental and Control Groups.

Group	N	$\bar{X}$	Std. Deviation	df	t	p
Experiment	48	8.17	3.34	90	1.99	0.65
Control	44	8.08	4.24			
Levene: 0.145						

Table 4. Comparison of Post-Test Scores of Students in Experimental and Control Groups.

Group	N	$\bar{X}$	Std. Deviation	df	t	p
Experiment group	48	14.35	2.67	90	2.32	0.021
Control group	44	12.0	4.26			
Levene: 0.001						

from the students, open coding was performed by reading the written texts line by line. The resulting codes were then grouped according to their relationship, and themes were formed. The students' responses to each interview question were evaluated by two raters. Inter-rater reliability refers to the fact that two or more coders provide codes for the database by analyzing the qualitative database, and coder results are compared to determine the level of agreement on the codes. The consistency evaluated using Cohen's Kappa statistic was found to be 0.88 and was considered to be in very good agreement (Creswell, 2016).

Findings

According to the results of the pre-test academic achievement test of the students in the experimental and control groups, it is seen that there was no statistically significant difference ($p > 0.05$) between the pre-test ($\bar{X} = 8.17$) mean scores of the students in the experimental group and the pre-test ($\bar{X} = 8.08$) mean scores of those in the control group [t (90) = 1.99, $p > 0.05$]. In addition, the p-value obtained from Levene's test is greater than 0.05 ($0.145 > 0.05$), indicating that the variances can be considered equal (homogeneous), allowing us to proceed with the assumption of equal variances for the t-test analysis (**Table 3**).

According to the post-test results of the experimental and control group students, there is a statistically significant difference ($p > 0.05$) between the post-test ($\bar{X} = 14.35$) mean scores of the students in the experimental group and the post-test mean scores ($\bar{X} = 12.00$) of the students in the control group [t (90) = 2.32; $p < 0.05$]. In addition, the p-value

Table 5. Comparison of Pre-Test and Post-Test Scores of Students in Experimental and Control Groups.

Groups	N	$\bar{X}$	Std. Deviation	df	t	p
Experiment Group						
Pre-Test	48	8.17	3.26	47	-3.47	0.00
Post-Test	48	14.35	2.67			
Control Group						
Pre-Test	44	8.08	3.93	43	-3.57*	0.00
Post-Test	44	12.0	4.26			

Table 6. Students' Thoughts about the Courses Taught with Simulation and Experiment Techniques.

Experiment Group				Control Group			
Themes	**Code**	**f**	**%**	**Themes**	**Code**	**f**	**%**
Positive Thoughts	Understood the Lesson Well	33	36.5	Positive Thoughts	Understood the Lesson Well	26	26
	Solving Questions Faster	24	25.8		Being in the Lab So Good	20	20
		21	22.6		Fun	19	19
	Seen More Clearly on Screen	15	16.1		Achieving Together	14	14
					Doing & achieving	13	13
					Socialization	8	8
Negative Thoughts	Classroom Disorder	9	24.3	Negative Thoughts	Noisy Environment	15	42.9
	Boring	8	21.7		Fear of Not Being Able	11	31.4
	Difficulty to Use Simulation	7	18.9		Fear of Breaking Materials	9	25.7
	Simulation Implementation Took Time	7	18.9				
	Time Loss	6	16.2				

obtained from Levene's test is less than 0.05 (0.001 < 0.05), indicating that the variances cannot be considered equal (not homogeneous), requiring us to use the assumption of unequal variances for the t-test analysis (**Table 4**).

In the pre-test and post-test paired sample t-test comparison for both groups of students, a statistically significant difference was found, and the mean achievement of the students in the experimental and control groups increased (**Table 5**). It is obvious that the only difference between the lesson plan in the experimental and control groups is the use of lab experiment and simulation.

The data obtained from the structured interview conducted with 3 open-ended questions to the experimental and control group students at the end of the lesson are presented below on a question basis. The percentages in **Table 6** represent the proportion of responses within each group for each question in our structured interview. Qualitative results aim to provide more insights into the interventions in both the experiment and the control groups. Our quantitative results show that students have positive opinions about both the simulation technique and the laboratory experiment applications. From the students’ responses, we can see that they were concerned about classroom management and time in both the simulation technique and the lab experiment.

Students’ thoughts about the course in which the simulation technique was applied were grouped under 2 themes: positive and negative. Positive thoughts were “Understood the lesson well; 36%”, “Solving Questions Faster; 25%”, “Fun; 22%”, “Saw It More Clearly on the Screen 16.1%”, while negative thoughts were “Classroom at Disorder; 24%”, “Boring; 21%”, “Difficulty to Use the Simulation; 18%”, Simulation Implementation Took Time; 18%”, and “Time Loss; 16%”. While the control group students’ positive thoughts about the lesson taught with the lab experiment were “Understood the Lesson Well; 26%”, “ Being in The Lab So Good; 20%”, “Fun; 19%”, “Achieving Together; 14%”, “Doing & Achieving; 13%”, and “Socializing; 8%”, the negative thoughts were “Noisy Environment; 42.9%”, “Fear of Not Being Able; 31%”, and “Fear of Breaking Materials; 25%” (**Table 6**).

Examples of some student statements

From Experiment Group:

Student-22: When I was using the program on the computer during the activity, everything was very clear, I could try again and again (positive thought).

Student-34: When I was using the program on the computer during the activity, my friends interfered a lot, I felt uncomfortable (negative thought).

From Control Group:

Student-17: It is already nice to go from the classroom to the laboratory, and doing experiments is very fun and easer to learn (positive thought).

Student-40: The laboratory is not as quiet as the classroom, and you need to use the materials carefully (negative thought).

In the answers given by the experimental group students, who had previously taught science courses using a limited number of lab-experiments and had never used simulation techniques, to the question “Compare the lessons taught with simulation and lab experiment, if you had to choose one of the two, which one would you choose?”, it was seen that 30 students out of 48 students (62.5%) preferred the lesson taught with simulation. In the context of this idea, the technology-supported simulation technique was preferred by the students in the experimental group.

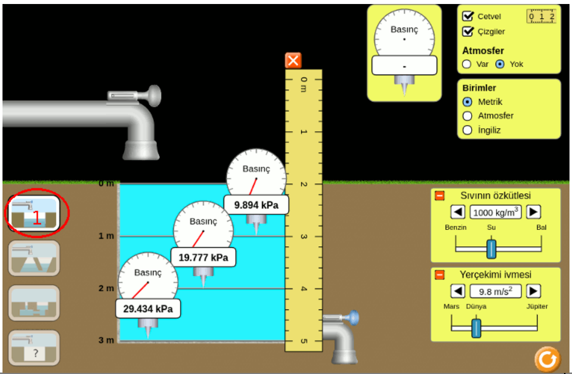

Figure 1. PhET simulation about Liquid Pressure.

Figure 2. Experiments of Liquid Pressure.

Figure 3. JavaLab simulation about Solid Pressure.

Figure 4. Experiments of Solid Pressure.

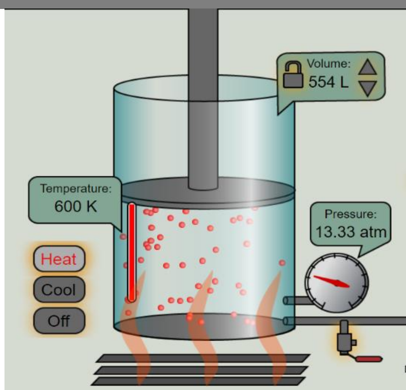

Figure 5. Formative simulation about Air Pressure.

Figure 6. Experiments of Air Pressure.

Discussion

The primary goal of this study was to compare the effectiveness of simulation and lab experiment techniques on students' academic achievement in a middle school science class (**Figures 1-6**). The findings revealed that the group using the simulation technique in the course is statistically significant in academic achievement compared to the group using the lab experiment. The difference can be attributed to the features of the simulation technique, such as the ability to recover quickly from accidents/mistakes that may occur, the motivation brought by the interest in computers in children, the ability to make clearer observations. Simulations and similar computer-based applications support flexible and diverse exhibition elements (Bakaç et al., 2011). For example, PhET simulations can provide concrete demonstrations, tacit scaffolding, engaging activities, and real-world connections that help learners comprehend concepts more easily (Moore et al., 2014; Perkins et al., 2014). Studies point out that diverse representation of knowledge can be effective on students' learning by enhancing learners' grasp of concepts in various ways, such as graphical, animative, and symbolic representations of knowledge (Cayvaz et al., 2020; Clark et al., 2009). This finding is in line with previous studies (Alsultanny et al., 2014; Arıcı & Yılmaz, 2020; Chang et al., 2008; Chernikova et al., 2020; Husnaini & Chen, 2019; Saiftri et al., 2020; Wang & Tseng, 2018). Cernikova et al. (2020) even claim that simulations are one of the most facilitative methods for learning. Analogously, Saiftri et al. (2020) conducted a study that compared simulations and lab experiments and found that simulations are more effective than lab experiments in aiding students' understanding of physics. Our finding also contradicts some other studies (Ambusadi et al., 2018; Kerr et al., 2004; Ma & Nickerson, 2006; Nanto et al., 2022; Putri et al., 2019). For instance, Nanto et al. (2022) found that simulations and lab experiments did not show any significant difference. Also, some studies show that lab experiments are better than simulations (Ratamun & Osman, 2018). However, these differences between environments do not necessarily arise solely due to the environment itself but can also be due to procedural differences between them, as stated by Hensen et al. (2020). Moreover, students found it easier to work with simulations and it facilitated their learning process even in complex subjects. This result is in line with the results of a study by Dyrberg et al. (2017) comparing laboratory experiments and simulations in biology courses. Dyrberg et al. said that students thought that working with simulations was much simpler than laboratory experiments. On the other hand, laboratory experiments involve setting up equipment and writing laboratory reports, which increases the difficulty of the task. A similar result is also seen in the study of Ambusaidi et al. Ambusaidi et al. reported that students found the learning process much easier and more engaging with the graphics and other representation components provided by simulations.

New technologies also draw the attention of students and engage them easily to complete given tasks. In Humpherys et al.'s (2022) study, students found simulations motivational, engaging, and enjoyable. Similarly, in this study, students stated that they had fun while using simulations. This finding also can explain why the simulation group is better in academic achievement because it is known that there is a relation between motivation, interest, enjoyment, and academic achievement (Amrai et al., 2011; Liu et al., 2022; Putwain et al., 2018; Schukajlow & Krug, 2014). However, some students found simulations tedious. This finding could arise from the struggle in using simulations, as some students reported spending much time trying to use them. A study by Nawaz et al. (2020) found that students who cannot resolve their confusion while using simulations may become disengaged. In this situation, it is suggested that teachers should be aware of students' behaviors and try to limit possible confusion.

In the lab experiment group, students reported that working together and socializing was enjoyable. Hands-on experiments abound in collaborative tasks (Walker et al., 2016), which was found to be the positive side of experiments by students in this study. They can communicate and discuss ideas with each other while conducting experiments, which may have created a positive dependency between them (Aydin, 2011). According to Hart et al.'s study (2000), students valued the collaborative nature of lab experiments. Similarly, in Raviv et al.'s study (2019), students expressed their fondness for group work.

Although students stated enjoyment with groups in lab experiments, there were also thoughts on fear of not accomplishing the experiment and causing harm to materials. Regarding this finding, Hussain et al. (2018) conducted a study to examine the anxiety of students in laboratory examinations, and they found that various factors can be influential on the anxiety of students. According to their results, five themes occurred during the lab experiment: (1) deficiency and unavailability of the equipment, (2) lack of practice, (3) harsh manners of laboratory personnel, (4) intense syllabus, and (5) absence of guidance. Some of these themes are in line with our findings. For example, students cannot feel comfortable while using materials as they think of the possibility of causing harm to equipment and getting fined for this situation. Due to materials being generally expensive and hard to make available for students and meagre in amounts, personnel of laboratories or teachers can be strict about using equipment, and this can affect students' behaviors while they are conducting experiments. Also, a lack of guidance and an overloaded syllabus can cause the feeling of not achieving the experiments. It is essential to prevent these situations as they can affect students' success and laboratory performance (Bowen, 1999).

Limitation

When analyzing the study's contributions, it is essential to recognize its limitations. One such limitation is that the intervention duration was a lesson hour; findings may differ when investigated on long-term interventions. One of these limitations may be due to the subject matter. The reason for the positive and negative thoughts of the students may be their perspectives on the subject of pressure due to their prior knowledge. Opinions about simulation or lab experiments on different topics may vary. Additionally, our study is limited by our sample and single district, preventing the generalization of our results. Future studies can conduct similar research with a larger sample.

Conclusion

This study investigated two questions: "Is there any difference between the academic performance of students who conducted lab experiments and those who used the simulation in their science lessons?" and "What are the opinions of students concerning interventions in the classroom?". Consequently, it was discovered that the simulation group achieved better academic results than the laboratory group, showing a significant difference in their academic performance. According to the obtained qualitative data, students have positive and negative opinions regarding simulations and lab experiment techniques. In both methods, students stated they understood the topics and found the methods fun. Nevertheless, the percentage was higher in the simulation group. Besides the positive aspects, some negative thoughts emerged for interventions. Some students found both experimental and simulation interventions chaotic and noisy, however, this ratio was much higher in the laboratory group than in the simulation group. The reason for observing both positive and negative thoughts in both interventions, despite the simulation group achieving better academic results, could be that students' opinions do not always reflect their academic achievement. This highlights the importance of considering both qualitative and quantitative findings to gain a more comprehensive understanding of the interventions.

When we examined the simulation group particularly, students indicated that they successfully resolved questions quickly and saw the topic more plainly on the screen, in addition to understanding the topic well and having fun while using simulations. However, there were also some negative perceived situations on the simulation side. Alongside finding intervention chaotic and noisy, students indicated that they struggled while using simulations, and using them takes time. Also, while some students stated they found simulations fun, some said it was tedious.

Regarding the laboratory group, students pointed out that they liked receiving the topic in the laboratory. Moreover, they stated how they liked working together and socializing. Lastly, they stated that there was a feeling of accomplishment at the end of the lab experiment. Similar to the simulation group, laboratory intervention had negative aspects perceived by students. In addition to finding it chaotic and noisy, students stated they were anxious about being unable to conduct the experiment and damaging the laboratory equipment. At the end of both interventions, students were asked about their preferred learning method, and 30 out of 44 students expressed their preference for learning through simulations.

The contribution of this study to the existing literature is its ability to showcase the potential of simulations on academic achievement. Incorporating simulations into classrooms is not avoidable through emerging cutting-edge technologies, and based on the evidence from our sample, we observed that simulations may have the potential to be more effective than lab experiments in improving academic achievement in the subject matter of pressure. Furthermore, the qualitative data revealed certain drawbacks of simulations and lab experiments as perceived by students. These can be considered by future studies while using simulations or lab experiments in interventions.

According to the results of this study, some findings can be further investigated in future research. For example, the reason students feel anxiety while conducting lab experiments can be investigated, and consider how to limit this feeling. Also, in this study, some students find simulations relatively hard to use and time-consuming. Therefore, further research can be conducted on whether simulations cause cognitive load or not.

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Received: February 20, 2025
Revised: March 07, 2025
Accepted: March 20, 2025