Jurnal Ilmiah ***Widya Pustaka Pendidikan***
ISSN : 2330–4500
Volume 13 No. 1. Januari-Juni 2025, p. 36-46

IMPACT OF VIRTUAL LABORATORIES ON SCIENCE PROCESS SKILLS AND INTEREST IN LEARNING SCIENCE AMONG PRIMARY SCHOOL STUDENTS

Ummiatul Fitri[1], Aissy Putri Zulkarnaini[2], Yanti Fitria[3], Inggria Kharisma[4]
[1,2,3,4] PGSD , FIP, Universitas Negeri Padang
Email: [1]ummiatulfitri@unp.ac.id, [2]aissyputri@unp.ac.id, [3]yanti_fitria@fip.unp.ac.id, [4]inggriakharisma@unp.ac.id

Abstract
This paper seeks to investigate the effectiveness of virtual laboratory in enhancing elementary school pupils' scientific process skills and interests in the learning of science. A quantitative approach employing a quasi-experimental design was adopted including two groups of pupils i.e. a group that utilized virtual laboratories and a group that was taught using the traditional methods. The research instruments comprised of the science process skills pretests, which were administered prior to the intervention, and science process skills post tests, which were administered after the intervention together with questionnaires that measured students' interest in the learning of science before and after the intervention. Data analysis was performed using percentage frequency, means and standard deviations, single factor ANOVA testing for homogeneity, independent t-tests and N-Gain to evaluate the level of effectiveness of the intervention. The findings highlight that the experimental group gained significantly more than the control group. The experimental group that employed the use of virtual laboratories had a higher mean posttest score of 0.67 indicating a high Ngain and thus higher science process skills acquisition. However the control group only showed a N-Gain of 0.20. Further, the analysis of the questionnaires showed an even greater gain in learning interest of members of the experimental group indicating that virtual laboratories enhance the acquisition of higher order skills through more active learning approaches. Research of this type suggests that technology-based media especially virtual laboratories can serve as an alternative for the improvement of student learning outcomes and interest in science education. Hence, the use of virtual laboratories can be seen as an innovative pedagogical approach that helps to increase target outcomes of 21st century education in science, in particular

Keywords: *virtual laboratory, science process skills, learning interest, science learning, elementary education*

INTRODUCTION

Elementary education is where students are exposed to core scientific concepts that are useful in their day to day lives and schools. The aim of science lessons is to challenge students in addition to offering them content but immersing them into problem solving approaches. For this to happen, there is a need to combine science with real life practice and in this instance focus on nature by doing out of class activities combined with measurements and interpreting such data. In practice however, (Mohzana dkk., 2023). This is particularly the case in the developing world where in most areas there are few or no science laboratories. Therefore, it becomes a challenge to carry out scientific principles

that are needed to enhance learner pity and understanding of concepts. Hence, these themes bring more of a constraint on evolution of the required science process skills or observations, classification, measuring and data analysis (DebBurman, 2002).

Several forms of technology-assisted learning have emerged owing to rapid advances in educational technology which help address the challenges posed by traditional instructional methods. One technology that is gaining popularity particularly in science education is the virtual lab. (Potkonjak dkk., 2016a). This innovation enables learners to engage in realistic and interactive lab activities through computer and related technologies without being constrained to physical laboratories. It follows that virtual laboratories make it possible for classrooms with few resources at their disposal to provide students with experimental actively. For science education, a virtual laboratory allows students to improve their science process skills development such as observing, controlling variables, measuring, and performing experiments in a virtual environment (Azizaturredha, 2019:Fachrunisa, 2018). Additionally, students' Science learning through virtual labs will be further enhanced because this approach to the approach is hoped to be more attractive to the learners since it is based on more active forms of learning.

An important area of focus during the education of the elementary students is related to the science process skills. These are the abilities that are stated above including observation, classification, measurement, experimentation and analysis and in as much as students would be able to use these skills; they will be able to make scientific explanations in different situations(Astuti, 2012). Constructivists' theory of learning as espoused by Piaget and Vygotsky emphasize that learning comes through doing and being in contact with the surrounding world (Zhou & Brown, 2015**)**. Virtual laboratories, which are viewed as an interactive experience, are therefore not only consistent with this theory but allow students to learn by guided discovery. It is also one of the fundamental factors that explain why students are willing to study and why they are successful in studying science subjects. A subject of high interest sinks well with students' engagement and enthusiasm in learning activities where they do not skim through but have a deep understanding of the material. virtual teaching applied in science studios has the potential to increase or create students' interest in the subject learning especially for elementary students who are more visually and game oriented.

Virtual laboratories have been found in the studies carried out in the past to be useful in improving the science process skills for learners and developing interest for science learning. Research conducted by (Elaish dkk., 2024) illustrates that the integration of virtual laboratories into the curriculum of science subjects enhances students' CPP considerably when compared to teaching science using traditional methods. This implies that virtual laboratories have the potential to offer students' hands on experience that is comparable to physical laboratories. However, another study carried out by (Potkonjak dkk., 2016b) concluded that virtual laboratories increase the interest of the learners in virtual learning environments as this approach allows for more creative simulation without the constraints of location and time. Other studies have also shown that students who are

taught through virtual laboratories tend to develop excitement and interest in learning because in most cases they are actively engaged in the academic work.

Although the use of virtual laboratories has been proved to be beneficial in a number of studies, their role in primary education still seems to be lacking in the literature. This is opposite of most research on virtual laboratories which has concentrated on form four and above with an aim in understanding of more sophisticated science. The use of virtual laboratories in primary schools is still under-researched, more so in the case of Indonesia, where most schools have infrastructural barriers that hinder the learning process. For a child in primary age, it would be important to understand the extent to which the virtual laboratories are able to develop scientific process skills and interest in learning which are crucial pillars of a child's academic development in the future. Thus, this study intends to address this by seeking to assess the effects of virtual laboratories on science process skills and interest for science learning of primary school pupils. Expect further light could be shed on the more general question of how virtual laboratories can be properly used in the current context of primacy schools which suffer from a real shortage of laboratory spaces.

METHOD

To explore whether Virtual Laboratories aided students' skills in science learning and how much interest they developed towards science, the researchers used a quantitative method with a quasi-experimental design. Under this design, two groups were formed, one which served as a control group and was taught using conventional methods and an experimental group which used Virtual Laboratories. The intervention incorporated collecting data through pretests that would seek to asses students' science process skills and questionnaires that would gauge the interest students had towards learning science before and after the intervention.

The data analysis desisted from simple analysis by actually involving phases analyzing the mean scores, standard deviations and percentage changes witnessed in the students results as was before and after pretest which was carried out through descriptive analysis. Normal distribution of the data was tested using Kolmogorov-Smirnov or Shapiro-Wilk tests and the data was also checked for homogeneity through Levene's Test to meet parametric requirements. Once data was found fitting for purpose, t-test was applied to check whether there were significant mean differences between the two groups assumed significant otherwise Mann-Whitney test was applied. Calculations involved in finding out the mean scores in N-Gain were then used to compare the two groups in terms of their differences in level of skills in science process and interest towards learning sciences.

The procedures followed in the analysis of data were first the data collection during the pretest, then the application of the treatment or the intervention to both the experimental group and the control group and then the collection of the final data during

posttest. In addition, normality and homogeneity tests were done. After that, N-Gain calculations were performed on the gathered data followed by hypothesis tests which were either t-tests or Mann-Whitney tests. The statistical findings permitted the researcher to make inferences regarding the impact that virtual laboratories had on students' science process skills and their interest in learning science.

In this particular study, the instruments were developed in such a way that they could quantitatively assess science process skills and learners' interest towards science learning. Table below shows the instruments utilized in his study, the aspects measured, type of data collected, scale of the measurements employed and the time data were collected. This set of instruments outlined the effectiveness of the application of virtual laboratories as a means to increase students' skills and their learning interests.

Table 1. Instrument

No	Instrument	Measured Aspect	Data Type	Measurement Scale	Data Collection Time
1	Science Process Skills Pretest	Observation skills like observing, classifying, and measuring	Quantitative	Interval	Before Intervention
2	Science Process Skills Posttest	Final abilities in science process skills after intervention	Quantitative	Interval	After Intervention
3	Science Learning Interest Questionnaire	Motivation, interest, and positive attitude toward science	Quantitative	Likert	Before and After Intervention

Once data was gathered using these instruments, this began the data treatment phase that aimed at interpreting the results. The pretest yielded the general picture of students' skills especially towards the target science process skills prior to the intervention while the posttest considered the variations in the science process skills that took place in the students after the intervention. The science learning interest questionnaire was done pre quasim and post quassim in order to gauge changes in attitude as well as motivation of students towards science learning. These instruments are very important in evaluating the efficacy of virtual laboratories as a learning medium which is believed will increase the skills and interest of students.

Table 2. Science Process Skills Pretest and Posttest Instrument

No	Science Process Skill Indicator	Activity Description	Minimum Score	Maximum Score
1	Observation	Observing objects and noting details	0	5
2	Classification	Grouping objects based on characteristics	0	5
3	Measurement	Measuring variables using appropriate tools	0	5
4	Data Interpretation	Presenting and analyzing data	0	5
5	Conclusion	Drawing conclusions from observations	0	5
	Total Maximum Score			25

The previously mentioned process of analysis and comparison of the pupils' process skills in science was carried out again this time but only in regard to the situation 25 (0-25). Each indicator defined the level of students' all rounded particular science process skills. These data results seek to evaluate changes in science process skills with the help of virtual laboratories, and these changes can be used as a reference point in working out better instructional techniques in the future.

RESULT

The purpose of the science learning interest questionnaire was to provide insight into students' engagement with and motivation for science learning. It included five key indicators: motivation to learn, interest in the subject matter content, positive attitude towards science, desire to learn more, and impression regarding the learning media. Each Indicator contained a predefined number of statements when the Third item sought to evaluate the use of a 5-point Likert scale (1-strongly disagree, 5-strongly agree). This tool is useful not only in defining students' engagement but also explains their learning and perceptions toward the subject of interest.

Table 3. Science Learning Interest Questionnaire

No	Learning Interest Indicator	Statement	Rating Scale	Minimum Score	Maximum Score
1	Learning	I am motivated to learn	1–5	1	5

	Motivation	science			
2	Interest in Material	I am interested in learning science topics	1–5	1	5
3	Positive Attitude	Science is an enjoyable subject	1–5	1	5
4	Desire to Learn More	I want to understand science more deeply	1–5	1	5
5	Perception of Learning Media	Using virtual laboratories makes science more interesting	1–5	1	5
	Total Maximum Score				25

Statistical data generated from this questionnaire made it possible to analyze students' shifts in interest toward science learning. The results of the questionnaire indicated the levels of motivation, interest and positive attitude of the students before and after the intervention activities with a total maximum score of twenty five. The results obtained were also utilized in analyzing the effectiveness of virtual laboratories as a medium of learning, as well as helping devise better strategies for teaching students that are more fun in the future.

The objective of this research is to determine the effect of virtual laboratories on students' science process skills and their interest in sciences. The data obtained from the pre-test, post-test of science process skills and the assessment of science interest questionnaire were used to evaluate the outcomes of the intervention. The assessment was done on two groups, that is, the group that was exposed to virtual laboratory and the one that was taught through conventional methods.

Table 4. Pretest and Posttest Results for Science Process Skills

Group	Pretest (Average)	Posttest (Average)	Change (Δ)	N-Gain
Experimental	12	22	+10	0.67
Control	12	15	+3	0.20

According to Table 4, it can be seen that both groups had a mean pretest score of 12 in science process skills. Following the intervention, the experimental group made notable progress, scoring an average of 22 in the post test, whereas the control group performed lesser with an average of 15 only. The increase in score for the experimental group (+10) was considerably more than for the control group (+3). The N-Gain score indicates a high increase for the experimental group at 0.67, while a low increase of 0.20 was recorded for the control group; this serves to underscore the positive effects of virtual laboratory in improving the science process skills of students.

Table 5. Science Interest Survey Results

Group	Before Intervention (Average)	After Intervention (Average)	Change (Δ)
Experimental	15	23	+8
Control	14	17	+3

Table 5 presents the findings for the science interest survey pre- and post the intervention. There was an increase in the average score of interest for the experimental group from 15 to 23 after the intervention. The control group only improved from 14 to 17. The change in interest for the experimental group (+8) was statistically superior to that of the control group (+3) which gives credence to the argument that the usage of the virtual laboratory had an impact on the students in terms of how they liked learning science.

Table 6. Summary of Results

Aspect	Group	Pretest (Average)	Posttest (Average)	N-Gain	Interest Before (Average)	Interest After (Average)	Change in Interest
Science Process Skills	Experimental	12	22	0.67	15	23	+8
	Control	12	15	0.20	14	17	+3

According to the data presented in Table 6, it is obvious that substantial enhancements in both science process skills (N-Gain of 0.67) and science interest (+8) were experienced among students in the virtual laboratory experiment group in comparison to the control group. This progress is an indication that new technologies in teaching, for example, virtual laboratories, not only improve the academic achievements of the students but also enhance their interest in and willingness to work on the subject.

Table 7. Descriptive Analysis of Science Process Skills

Group	Pretest (Average)	Pretest Standard Deviation	Posttest (Average)	Posttest Standard Deviation	Percentage Change (%)
Experimental	12	2.00	22	1.50	83.33
Control	12	1.80	15	1.20	25.00

All subjects had an average of 12 points in the pretest. However, post interventional measures, the post-test mean score for the experimental group increased distinctly to 22 whereas the control achieved only 15. The percentage change demonstrates an exponential rise

for the experimental group at 83.33 percent unlike the control at 25 percent. This suggests the enhancement of students' science process skills learning through the application of virtual laboratories.

Table 8. Normality Test Results

Group	Kolmogorov-Smirnov Statistic	p-value	Conclusion
Experimental	0.150	0.082	Normal
Control	0.120	0.200	Normal

Both groups show normal data distribution, with p-values greater than 0.05, allowing for the use of parametric analysis.

Table 9. Homogeneity Test (Levene's Test)

Group	F-value	p-value	Conclusion
Science Process Skills	1.200	0.275	Homogeneous

The variance between the groups is homogeneous, evidenced by a p-value > 0.05, permitting the use of an independent sample t-test.

Table 10. Independent Sample t-test Results

Group Comparison	Posttest Average	Pretest Average	t-value	p-value	Conclusion
Experimental vs Control	22	12	6.35	0.000	Significant ($p < 0.05$)

There is a significant difference between the experimental and control groups in science process skills, with a t-value of 6.35 and $p < 0.05$. This confirms the significant impact of using virtual laboratories on student learning outcomes

DISCUSSION

These findings are in line with previous studies which also enhances the argument of virtual laboratories' positive effects in regard to science learning. (ismail dkk., 2016) showcased that science learning achievement can be improved utilizing various instructional media including virtual laboratories. Their study highlights the fact that virtual labs are working due to their captivating and interactive features that facilitate the students' comprehension of science as a difficult discipline. In the same manner, (Fatimah Dkk., 2024) compared two groups of students using virtual laboratories and conventional practices in science learning and concluded that the first group was more motived than the second one. Students were more willing to participate and were more interested in the content

because of the increased interactivity allowed, which also coincides with the findings of this study, which demonstrated great difference in interest between the two groups. Moreover, (De Jong Dkk., 2013) Added That The Use Of Virtual Laboratories Not Only Improved Practical Skills But Provided a better grasp of the scientific method. This way this study provides a useful experience of carrying out an experiment individually, thus allowing students to gain a better appreciation of the processes of research and data gathering. However, (Suprapno Dkk., 2021) pointed out issues related to the use of virtual labs. Though some advantages were mentioned, the absence of appropriate technology resource and poor digital literacy of both learners and their teachers may preclude successful usage. This highlights the reliability of technological aid and the necessity of adequate teacher training in order to fully utilize virtual labs. At the same time, (Fertina, 2023) studied the effect of virtual labs on collaborative learning. The research revealed that the students who participated in the science education process through virtual labs collaboration not only enhanced their science process skills but also social skills which included communication and teamwork. All in all, this research reinforces the idea that virtual laboratories are important for science education , as long as the technical aspects and teacher training are properly developed.

CONCLUSION

In light of the research results and data assessment, it can be stated that virtual laboratories have been efficient in improving the science process skills, as well as in the interest of the learners to the science content. The improvement of science process skills, as measured by the performance of pretest and posttest ratings, also reflects the fact that the experimental group which made use of the virtual laboratories scored considerably better than the control group which used the traditional methods of teaching. Such an increase may be ascertained through improvement in mean, change in scores, and a large N-Gain value. Moreover, the data from the interest survey indicates that the students' motivation and even sentiment towards learning science has also improved in the experimental group. It was found that the use of the virtual laboratory had a positive effect on students in terms of their interest and attitude towards science learning because of the more interactive and participatory nature of instruction. This is consistent with the side effects of some other previous studies which indicated that virtual laboratories are beneficial in the learning process as they enhance understanding of concepts as well as stimulate interest and self efficacy in the student. In general, these results enhance practical teaching strategies that are new and technology-based in the field of science education. The employment of virtual laboratories may be seen as relevant and useful in circumstances that require more ease of access to laboratory facilities. Such results confirm the necessity to foster a culture of technological application in education especially in science education in the context of digitalization and its significance in equipping learners with key competencies of the 21st century applicable in various sectors and professions.

ACKNOWLEDGMENTS

We extend our thanks to the dean of the faculty of education of Universitas Negeri

Padang, Prof. Dr. Afdal, M.Pd., Kons., who has permitted this research to be conducted and this journal to be submitted, as well as to the colleagues who supported and contributed to the writing of the journal.

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