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The Influence of Virtual Laboratory-Assisted Collaborative Learning Model on High School Students' Physics Learning Outcomes

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ABSTRACT

Low physics learning outcomes in high schools are often due to lecture-dominated methods, limited lab facilities, and students' perception of physics as abstract and difficult This study aims to determine the effect of the Collaborative Learning model assisted by Virtual Laboratory on the learning outcomes of class XI students at SMA Negeri 2 Banda Aceh. The population of the study was all class XI IPA students, with a purposive sampling technique. Class XI MIPA Brunei Darussalam (33 students) was the experimental class, and XI MIPA Hongkong (26 students) was the control. Data were collected through learning outcome tests, observations, and interviews. Data analysis used the normality test (chi-square), homogeneity test (F) and t-test. The average posttest score for the experimental class was 77.58 while the control class obtained 65.38. Furthermore, the results of the hypothesis test using the t-test showed tcount 4.3> ttable = 1.673 (α= 0.05), so it is concluded that the Collaborative Learning model assisted by Virtual Laboratory has a significant effect on improving students' physics learning outcomes. Observation of implementation reached 99.5%, and interviews showed that students were more motivated and understood the concept better. Thus, Collaborative Learning with Virtual Lab effectively improves students' physics learning outcomes.

1. INTRODUCTION

Physics learning in senior high schools plays a crucial role in shaping students' scientific literacy, critical thinking, and problem-solving abilities. Through physics, students learn to understand natural phenomena based on observation, experimentation, and reasoning (Hutapea & Panjaitan, 2025). However, despite its importance, the learning outcomes of physics in Indonesian high schools remain unsatisfactory. Many students perceive physics as difficult, abstract, and less relevant to daily life, which reduces their motivation and active participation in class (Sasmi et al., 2025; Karwasz & Wyborska, 2023). This perception is reflected in the results of preliminary observations and interviews at SMA Negeri 2 Banda Aceh, where the average student score in physics was 52.5, and only 50% of students achieved the Minimum Mastery Criteria (KKM) of 75. These findings illustrate that students' understanding of physical concepts is still low, indicating the need for improvements in instructional design.

Several factors contribute to these low learning outcomes. First, physics teaching is still dominated by teacher-centered methods such as lecturing and textbook-based explanation, which limit student involvement and independent inquiry (Wahyuni, 2021). Second, students face difficulties in visualizing abstract concepts such as pressure, force, and buoyancy without direct experimental experience. Third, the lack of adequate laboratory facilities prevents students from conducting real experiments that can concretize those concepts. According to data from the Ministry of Education and Culture, only 45% of high schools in Indonesia have well-equipped physics laboratories (Sani, 2021). This condition not only limits the quality of science learning but also widens the gap between theory and practice, which ultimately affects students' scientific reasoning skills and curiosity.

Addressing these issues requires innovative learning models that not only enhance students' cognitive understanding but also encourage collaboration, communication, and active engagement. One potential strategy is the Collaborative Learning model, which emphasizes learning through teamwork and shared problem-solving. In this model, students are responsible for each other's understanding and work together to achieve learning goals (Alfira, 2020; Barkley et al., 2012). Collaborative learning provides opportunities for students to express ideas, discuss misconceptions, and construct knowledge collectively. Nevertheless, collaboration alone may not be sufficient to overcome the lack of experimental opportunities in physics classrooms.

To support the learning process and overcome infrastructure limitations, the use of Virtual Laboratory media has become an effective alternative. The Rumah Belajar platform developed by the Ministry of Education and Culture of the Republic of Indonesia offers various virtual lab features aligned with the national curriculum, including interactive simulations for static fluid topics such as hydrostatic pressure and buoyancy (Aini, 2021; Zahro, 2023). This platform allows students to perform virtual experiments anytime and anywhere using laptops or smartphones, providing a flexible and engaging learning experience. Research has demonstrated that virtual laboratories can improve students' conceptual understanding, inquiry skills, and motivation by visualizing abstract phenomena in a realistic and interactive way (Asare et al., 2023; Meilina et al., 2023; Santiari et al., 2022).

Although numerous studies have discussed the effectiveness of Collaborative Learning and Virtual Laboratories separately, empirical evidence on the integration of both approaches remains limited especially in the context of physics learning at the high school level. Most previous research focuses only on individual effects of collaboration or digital media without exploring how the two can synergistically enhance learning outcomes. In fact, integrating Collaborative Learning with Virtual Laboratories can potentially create a learning environment where students engage actively, experiment virtually, and build conceptual understanding through peer interaction and reflection.

Therefore, this study aims to determine the effect of the Collaborative Learning model assisted by Virtual Laboratory on the physics learning outcomes. The combination of these two approaches is expected to overcome the challenges of limited laboratory facilities while promoting an interactive, meaningful, and technology-based learning process. Moreover, this research provides practical implications for developing effective, scalable, and innovative learning strategies that align with the needs of 21st-century science education in Indonesia.

2. METHODS

2.1 Research methods

This study was conducted using a quasi-experimental pretest-posttest control group design. The research process began with the provision of pretest questions to both groups (experimental and control) to determine students' initial abilities. After that, the experimental class was given treatment in the form of implementing the Collaborative Learning learning model assisted by a Virtual Laboratory while the control class used the Collaborative Learning method without a virtual laboratory. This study was conducted at SMA Negeri 2 Banda Aceh, with a population of all students of class XI IPA. The sample was selected by purposive sampling, namely class XI MIPA Brunei Darussalam (33 students) as the experimental class and class XI MIPA Hongkong (26 students) as the control class. The sample selection was based on the equality of academic ability, as suggested by Fraenkel et al. (1993), that purposive group selection can be considered equal in ability. The data collection instrument was in the form of multiple-choice learning outcome test questions that had been validated by experts, as well as observation sheets and interview guides. Data analysis used several stages, namely: normality test, homogeneity test, and hypothesis t-test to test the significance of the differences between the exsperimental and control classes. The table is written in the form shown in Table 1.

Table 1. Pretest-posttest control group design

Pretest subject	pretest	treatment	posttest
Experiment	O_1	X	O_2
Control	O_3	-	O_4

Source: Fraenkel, et al, 2012

Information:
O_1: pre-test experimental class
O_2: pre-test control class
O_3: post-test of experimental class
O_4: post-test control class
X : treatment

The virtual practicum sessions in this study were carried out using the *Virtual Laboratory* feature available on the Rumah Belajar platform developed by the Ministry of Education and Culture of the Republic of Indonesia. The implementation was conducted in two 90-minute meetings and integrated into the Collaborative Learning model steps. Students accessed the virtual lab using laptops and smartphones connected to the school's Wi-Fi network. During the sessions, students were divided into small groups consisting of four to five members. Each group collaboratively explored the topic of static fluids through interactive simulations designed to visualize abstract physics concepts. The virtual experiments included two main simulations, namely hydrostatic pressure and buoyancy (Archimedes' principle). In the hydrostatic pressure simulation, students manipulated the height of the liquid column and observed the resulting pressure changes using a virtual manometer displayed on the screen. In the buoyancy simulation, students adjusted the mass of objects, the density of fluids, and the volume of displaced liquid to observe changes in the buoyant force and determine the conditions under which objects floated or sank.

In these simulations, the independent variables that could be manipulated by students were the height of the liquid and the density of the fluid, while the dependent variables were the pressure and buoyant force generated as outcomes. The *Rumah Belajar* interface provided a simple and intuitive display that allowed students to interact directly by dragging virtual objects, inputting numerical data, and resetting the experiment for repeated trials. The simulation automatically displayed the experimental results both numerically and graphically, enabling students to analyze and interpret data collaboratively. Each group recorded their observations in a worksheet provided by the teacher and discussed their findings before concluding the experiment.

The learning implementation sheet was in the form of an observation sheet that aimed to determine the extent to which the level of learning implementation used the Collaborative Learning model assisted by virtual laboratories. The assessment data provided by the observers were then processed using Equation [1] and interpreted using the criteria in Table 2.

$$\text{Percentage Value} = \frac{Number\ of\ learning\ stage\ values}{number\ of\ learning\ stage} \times 100\ \% \qquad (1)$$

Table 2. Criteria for Learning Implementation Score

Answer Selection	Score
Very good	4
Good	3
Not good	2
Not good	1

Source: Sugiono, 2015: 135

3. RESULT AND DISCUSSION

3.1 Learning Outcome Test Results

The results of the pretest and posttest were used to determine the extent to which student learning outcomes had improved after the application of different learning models in each class. The experimental class used the Collaborative Learning model assisted by Virtual Laboratory, while the control class only used Collaborative Learning without the assistance of digital media. The pretest score showed students' initial abilities before the treatment, while the posttest was used to measure students' understanding after the learning process. Calculation resultsaverage learning outcomes of students in experimental and control classespresented in Table 3 below.

Table 3. Average learning outcomes of students in experimental and control classes

Statistical data	Pretest Control		Posttest	
	Control	Experiment	Control	Experiment
The highest score	60	80	70	100
Lowest value	10	20	40	50
Average	32.69	48.48	65.38	77.58

Table 3 shows that there was an increase in the average value in both classes after learning. However, the increase in learning outcomes in the experimental class was higher than in the control class. This indicates that the use of Virtual Laboratory in learning provides a greater contribution to students' understanding of concepts.

Before hypothesis testing is carried out, prerequisite tests are carried out in the form of normality and homogeneity tests. The normality test aims to determine whether student learning outcome data is normally distributed, while the homogeneity test is used to determine the similarity of variance between groups. The normality test is carried out using the Chi-Square test at a significance level of 0.05. The calculation results are presented in Table 4.

Table 4. Chi-Square Normality Test Results

Class	χ^2count	χ^2table (α= 0.05)	Conclusion
Pretest Experiment	4.71	11,070	Normal
Posttest Experiment	4.34	11,070	Normal
Pretest Control	6.92	11,070	Normal
Posttest Control	5.88	11,070	Normal

Based on Table 4, all valuesχ^2count less thanχ^2table, so it can be concluded that the data on student learning outcomes in both classes (experimental and control) are normally distributed. The homogeneity test was conducted using the F test. The test results showed that Fcount = 1.33 and Ftable = 1.95. Because $F_{count} < F_{table}$, it can be concluded that the data has a homogeneous variance

After the data was declared normally distributed and had homogeneous variance, a hypothesis test was conducted to determine the differences in student learning outcomes between the experimental class and the control class. The test used was the independent sample t-test at a significance level of 0.05. The results of the statistical analysis using the t-test showed that the t_{value} of 4.3> t_{table} 1.673 at a significance level of 0.05. Thus, there is a significant difference between the learning outcomes of students who use the Collaborative Learning model assisted by Virtual Laboratory and students who learn without using Virtual Laboratory.

Overall, these results provide empirical evidence that the integration of Virtual Laboratory in a collaborative learning model is effective in improving students' understanding of static fluid concepts. The visualization and simulation of experiments provided by Virtual Laboratory allow students to explore the material more concretely, thereby strengthening their mastery of concepts through a more active and meaningful learning experience.

3.2 Results of Observations on Learning Implementation

Observation of the implementation of learning was carried out by one observer who was tasked with observing the implementation of the Collaborative Learning model assisted by Virtual Laboratory in physics learning in class XI MIPA Brunei Darussalam, SMA Negeri 2 Banda Aceh. Observations were carried out during two meetings in the experimental class. The purpose of this observation was to assess the extent to which the implementation of the syntax of the learning model was in accordance with the established design. The results of the Analysis of the Implementation of the Collaborative Learning Model assisted by virtual laboratories are presented in Table 5.

Table 5. Results of the Analysis of the Implementation of the Collaborative Learning Model Assisted by Virtual Laboratories.

No	Learning Activities and Syntax	P1	P2	Implementation of Learning Model		Information
				Average Score	(%)	
1	Preliminary Activities	4	4	4	100	Very good
2	Core activities	4	4			Very good
	Phase I. Student orientation	4	4	4	100	Very good
	Phase II. Forming groups	4	4	4	100	Very good
	Phase III. Compiling learning tasks	4	4	4	100	Very good
	Phase IV. Facilitating student collaboration	4	3.75	3.87	96.87	Very good
	Phase V. Assessing and evaluating	4	4	4	100	Very good
3	Closing Activities	4	4	4	100	Very good
Average				3.98	99.5	Very good

The observation results showed that all syntax of the Collaborative Learning model assisted by Virtual Laboratory was implemented with the category of "very good" in both meetings. The average learning implementation reached 99.5%, which reflects that the implementation of the model ran according to the designed scenario. All stages of learning, from preliminary to closing activities, were implemented consistently and effectively. This activity supports active student involvement in the learning process and reflects that the collaborative approach implemented successfully creates a participatory and meaningful learning atmosphere.

Although the implementation of the Collaborative Learning model assisted by Virtual Laboratory achieved a very high percentage of 99.5%, several challenges were encountered during the learning process. Some students initially experienced technical difficulties in accessing the Rumah Belajar platform due to unstable internet connections and limited device specifications, which caused delays during simulation activities. In addition, a few students required additional time to become familiar with the interface of the virtual laboratory, particularly in manipulating variables and recording results correctly. From the collaborative aspect, group dynamics were not always equally effective; in certain groups, dominant students tended to take control of the simulation, while others became more passive. The teacher's role was therefore crucial in ensuring balanced participation and guiding technical troubleshooting. These challenges, although relatively minor, provide valuable insights that the integration of virtual laboratories in collaborative learning requires adequate technical support, stable internet access, and continuous scaffolding to ensure all students can engage equally and effectively in digital-based physics learning.

3.3 Interview Results

Interviews were conducted as supporting data to analyze the practicality and effectiveness of the Collaborative Learning model assisted by Virtual Laboratory in physics learning. This activity was carried out after two learning meetings in the experimental class. Five students were selected as respondents and given five open-ended questions related to their experiences in learning with the model.

The interview results showed that the majority of students gave a positive response to the implementation of the Collaborative Learning model assisted by Virtual Laboratories. In terms of understanding the material, students stated that the use of Virtual Laboratories helped them understand abstract concepts more easily because the material was presented visually and interactively. Simulations that can be repeated at any time also provide students with the flexibility to learn at their own pace.

Students also stated that this model is feasible to be applied to other subjects, especially those that require experimental activities and concept visualization. Collaboration built in groups and the support of digital media make learning more effective and efficient.

In general, the results of this study support and strengthen previous findings (Barkley et al., 2012) that the integration of technology and collaboration in learning can improve learning outcomes and the quality of students' learning experiences. This finding is in line with the research of Santiarai et al. (2022) and Meilina et al. (2023) that the use of virtual laboratories can increase the effectiveness of science learning. In addition, collaborative learning also encourages active involvement and constructive social interactions between students, as reflected in the results of observations and interviews in this study.

Overall, the interviews confirmed that the Collaborative Learning model assisted by Virtual Laboratory was able to improve students' understanding, motivation, and participation in physics learning. Respondents felt that this model was relevant to their learning needs and supported the creation of a more engaging, safe, and cost-effective learning experience.

4. CONCLUSION

This study shows that the Collaborative Learning model assisted by Virtual Laboratory has a significant effect on students' physics learning outcomes in static fluid material. Students who take part in learning with this model experience a better understanding of concepts compared to students who learn without the help of Virtual Laboratory. Learning becomes more effective because students can visualize concepts through digital simulations, actively participate in group discussions, and explore materials independently. Observations of the implementation show that the implementation of learning is very optimal, and interviews reveal that students feel more motivated, helped, and interested during the learning process. Therefore, this model is considered not only to improve learning outcomes, but also to create an interactive, efficient, and inclusive learning atmosphere, so that it is worthy of being applied in physics learning and other subjects that are conceptual and experimental.

REFERENCES

Aini, Y. I. (2021). Pemanfaatan rumah belajar pada pembelajaran di masa adaptasi kebiasaan baru. *Jurnal Teknodik*, 81-93. https://doi.org/10.32550/teknodik.v25i1.785

Alfira, N. (2020). Pengaruh model pembelajaran kooperatif terhadap hasil belajar siswa. *Jurnal Pendidikan Sains Indonesia*, 8(1), 45–52. https://doi.org/10.33751/jsep.v4i1.2827

Ansori, A., Sabrifha, E., & Junadi, M. (2025). Peningkatan Hasil Belajar IPA Melalui Penerapan Model Pembelajaran Student Team Achievement Division (STAD). *Jurnal Kependidikan*, 13(1), 149-164. https://doi.org/10.24090/jk.v13i1.12465

Aprilianto, D., Hanifah, U., Indriyana, O., & Ratri, M. K. (2021). Rumah Belajar dan Penggunaannya dalam Memperbaiki Kualitas Pendidikan Peserta Didik. *JIRA: Jurnal Inovasi dan Riset Akademik*, *2*(10), 1453-1459. https://doi.org/10.47387/jira.v2i10.233

Asare, S., Amoako, S. K., Biilah, D. K., & Apraku, T. B. (2023). The use of virtual labs in science education: A comparative study of traditional labs and virtual environments. International Journal of Science Academic Research, 4(11), 6563-6569. http://www.scienceijsar.com/

Barkley, E. F., Cross, K. P., & Major, C. H. (2012). *Collaborative learning techniques: A handbook for college faculty (2nd ed.).* Jossey-Bass.

Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2012). *How to design and evaluate research in education (8th ed.)*. New York: McGraw-Hill.

Ghaleb, B. D. S. (2024). Effect of exam-focused and teacher-centered education systems on students' cognitive and psychological competencies. *International Journal of Multidisciplinary Approach Research and Science*, *2*(2), 611-631. https://doi.org/10.59653/ijmars.v2i02.648

Giancoli, D. C. (2001). *Physics: Principles with applications (5th ed.).* Pearson Education.

Hutapea, P., & Panjaitan, M. (2025). The Effect of the Group Investigation (GI) Type Cooperative Learning Model Based on Experimental Skills on Generic Skills in the Kinetic Theory of Gases Material in the Classroom XI Interest IPA Senior High School Negeri 3 Medan Semester II Academic Year 2024/2025. *Edumaniora: Jurnal Pendidikan dan Humaniora*, *4*(01), 43-52. https://doi.org/10.54209/edumaniora.v4i01.96

Karwasz, G. P., & Wyborska, K. (2023). How constructivist environment changes perception of learning: Physics is fun. Education Sciences, 13(2), 195. https://doi.org/10.3390/educsci13020195

Meilina, I. L., Rohmah, A. A., & Farikha, N. (2023). Studi Literatur Efektivitas Virtual Laboratorium Pada Pembelajaran Fisika. *Jurnal Ilmu Pendidikan Dan Pembelajaran*, *1*(2), 40-50. https://doi.org/10.58706/jipp.v1n2.p40-50

Sandari, T. (2021). Pemahaman Siswa Terhadap Hasil Belajar Fisika Pada Materi Besaran dan Satuan di SMA N 1 Batanghari. *Integrated Science Education Journal*, 2(3), 94-97. https://doi.org/10.37251/isej.v2i3.176

Sani, R. A. (2021). Pembelajaran berorientasi akm: asesmen kompetensi minimum. Bumi Aksara

Santiari, M., Sele, Y., Moi, M. Y., & Masing, F. A. (2025). Aplikasi Laboratorium Virtual dan Laboratorium Non Virtual: Suatu Solusi Pemberdayaan Kemampuan Profesional Guru di SMPN Nunbai. *Sewagati*, *9*(4), 1022–1031. https://doi.org/10.12962/j26139960.v9i4.4681

Sasmi, R. R., Shiha, S. N., Saregar, A., & Deta, U. A. (2025). Perspektif Siswa SMA Terhadap Kearifan Lokal, Literasi Sains, dan Motivasi Belajar dalam Pembelajaran Fisika. Reog: *Journal of Ecoethnoscience Education*, 1(1), 32-39. https://doi.org/10.58706/reog.v1n1.p32-39

Sugiyono. (2015). *Metode penelitian pendidikan: Pendekatan kuantitatif, kualitatif, dan R&D*. Bandung: Alfabeta.

Syaadah, R., Ary, M. H. A. A., Silitonga, N., & Rangkuty, S. F. (2022). Pendidikan formal, Pendidikan non formalDanPendidikan informal. *Pema*, *2*(2), 125-131.. https://doi.org/10.56832/pema.v2i2.298

Tavares, M. C., Azevedo, G., & Marques, R. P. (2022). The challenges and opportunities of era 5.0 for a more humanistic and sustainable society—a literature review. *Societies*, *12*(6), 149. https://doi.org/10.3390/soc12060149

Wahidah, A. N., Ashari, A., & Kurniawan, E. S. (2023). Implementasi Laboratorium Maya Rumah Belajar Untuk Meningkatkan Kemampuan Psikomotorik dan Kemampuan Berpikir Kreatif Peserta Didik. Jurnal Inovasi Pendidikan Sains (JIPS), 4(2), 54-61. https://doi.org/10.37729/jips.v4i2.3421

Zahro, F., Ambarwati, T. S., & Septianingrum, J. (2023). Efektivitas Penggunaan Media Alat Peraga “Perahu Rakit” dan Laboratorium Maya pada Materi Hukum Archimedes. *Jurnal Ilmu Pendidikan Dan Pembelajaran*, *1*(2), 66-76. https://doi.org/10.58706/jipp.v1n2.p66-76