Berkala Ilmiah Pendidikan Fisika
ISSN : 2337-604X (print)
ISSN : 2549-2764 (online)

Vol 10 No 3 2022
https://ppjp.ulm.ac.id/journal/index.php/bipf
page 331-341

Effectiveness of Using E-learning at STEM-Based Sound-Wave Materials to Improve Collaboration Skills of High School Students

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DOI:10.20527/bipf.v10i3.13850

Received: 6 July 2022 Accepted: 17 November 2022 Published: 29 December 2022

Abstract

This study aims to see the effectiveness of STEM-based sound wave e-learning in improving the collaboration skills of high school students. The effectiveness test sample consisted of 30 SMAN 2 Palembang students selected with purposive sampling techniques. A collaborative skills rubric with three observers from Sriwijaya University's Master of Physics Education was the tool employed in this study. This study tested the effectiveness of using e-learning at STEM-Based Sound-wave materials to enhance students' established cooperation abilities. The t-test and N-Gain test are used for more reliable measurements to determine effectiveness. The t-test showed a significant increase in students' collaboration skills after being given treatment using e-learning at STEM-Based Sound-wave materials with t_{count} = 30.377, and the significance level was smaller than 0.05. N-Gain test showed that the e-learning at STEM-Based Sound-wave materials that had been developed significantly improved the collaboration skills of high school students with an N-Gain score of 0.68 in the medium category. The highest increase in the contribution aspect with an N-Gain score of 0.85, and the lowest in working with others with an N-Gain score of 0.62. These results showed that STEM-based sound wave e-learning is a good learning media option in physics learning to improve students' collaboration skills. It is recommended that further research be conducted on other 21st-century skills to find effective learning methods and media in responding to the challenges of life in the 21st century.

Keywords: Collaboration Skills; E-learning; Development; Sound Waves; STEM

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How to cite: Hidayah, R. N., Wiyono, K., & Ismet, I. (2022). Effectiveness of using e-learning at stem-based sound-wave materials to improve collaboration skills of high school students. *Berkala Ilmiah Pendidikan Fisika*, *10*(3), 331-341.

INTRODUCTION

The twenty-first century, often known as the "period of the 4.0 revolution," has generated a lot of debate around the globe, including in Indonesia. Although the global current has been going on since the 18th century (Prasetyo & Trisyanti, 2018), it is defined by growing connectedness, interaction, and development of digital systems, as well as artificial and virtual intelligence (Lase, 2019) through intelligent engineering and the internet of things that make it simpler for individuals to carry out their activities with more effectiveness and efficiency time (Cholily et al., 2019). Future people may rely primarily on

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technology to meet their requirements in the twenty-first century.

Science and technological progress catalyze the revolutionary paradigm's ongoing, irregular development as a proponent of renewal (Liao et al., 2018). The education industry then takes the lead in bringing about this paradigm shift. As this revolutionary era develops, the field of education is still under pressure to enhance its system (Cholily et al., 2019). A teacher should be able to use a suitable learning strategy for their student's intelligence types to make the teaching process more effective (Wiyono et al., 2019).

E-learning is then quite interesting in choosing learning media that can increase learning effectiveness. E-learning is the use of the internet to distribute learning materials so that they can be accessed from anywhere (Permana, 2009), making communication between educators and students more optimal (Alqudah, et al., 2020; Fandio & Velandia, 2020; Kacetl & Semradova, 2020), and can be a pedagogical strategy, it has greater appeal and is considered necessary to be applied in learning activities at school and even at higher education levels (Nuangchalerm, et al., 2014).

With e-learning, learners will get a new experience in learning where there are no limitations of space and time(Amelia & Gufron, 2018; Goda, et al., 2015; Hadisi & Muna, 2015; Tran, et al., 2020). So, e-learning is one of the digital platforms needed as one of the educator's pedagogic strategies to improve learning more effectively by using the internet.

However, when viewed from internet use in Indonesia, the results of a survey conducted by the Association of Indonesian Internet Service Providers in 2019-2020 showed that of the 73.7% of Indonesians who use the internet, 95.4% of them use mobile phones as a medium. However, it was noted that only 5.2% used the internet for educational contexts(Association of Indonesian Internet Service Providers, 2020). So, there is still little interest in using the internet in education. Even this technology should be a demand for the 4.0 educational revolution era (Wiyono & Zakiyah, 2019), which has entered an era where various information and communication technology-based innovations are taking place very rapidly (Ilyasir, 2019), so e-learning is expected to be STEM-based (Widayanti, et al., 2019) which is an integration between science, technology, engineering, and mathematics (Winarni et al., 2016).

STEM is seen as alternative learning that can build a generation facing the challenging 21st century (Mulyani, 2019) because STEM integrates those 21st-century skills (Utami, et al., 2017). Applying STEM-based learning is appropriate, especially to meet the needs of achieving skills that are increasingly developing in the 21st century. One of the key skills of the 21st century is collaboration skills. However, it was found that one of the competencies that a high school, diploma, and higher education graduate still needs to improve is working together or collaborating (Trilling & Fadel, 2009). At the same time, students will learn better if they are actively involved in the learning process in small groups (Septikasari & Frasandy, 2018). So, to increase the attractiveness of using the internet in learning, STEM-based e-learning is the right hope in supporting learning effectiveness in the 21st century.

The effectiveness of learning, which is one of the benchmarks for learning success (Elzainy, et al., 2020; Fitri, 2021; Harahap, 2015), is usually marked and measured by the achievement of goals by most students (Setyosari, 2014). More than just increasing learning outcomes, effective learning will also produce behavioural and psychomotor changes from the learning outcomes that he gets

from his own experience and from his environment that brings certain effects, meanings, and benefits (Joseph, 2017). So, effectiveness which has been the benchmark for learning success does not only talk about learning outcomes but also about behavioural and psychomotor changes that will bring certain benefits to a person and the environment. Therefore, effective learning planning (both in terms of models, methods, media selection, and so on) becomes an inevitable urgency.

Several studies related to e-learning, STEM, and/or its relation to the collaboration skills of students in the 21st century have been carried out (Amri, et al., 2015; Hartanto, et al., 2021; Tiari, et al., 2020) produce e-learning that is valid, practical, and effective. Then the research shows that there is a positive response to the implementation of STEM and e-learning (Wibowo, 2018) and the application of STEM-based physics learning can improve students' collaboration skills (Cholis & Yulianti, 2020). However, in this study, research has yet to be found linking the results of this development with its effectiveness in improving students' collaboration skills. In some of these previous studies, there is a link between e-learning, STEM, and 21st-century skills, including student collaboration skills.

As an example of the use of technology in learning, E-learning which is included in the STEM (Science, Technology, Engineering, and Math) component, tends to use PBL and/or PBL models. In contrast, problem-based and project-based learning models involving group activities or collaborative work can spur students to develop collaborative skills (Scott, 2015). The learning characteristics of the PjBL-STEM model, which focuses on the 'student-centred model', significantly influence problem-solving skills (Putri & Dwikoranto, 2022). The use of STEM approach using the PBL learning model can be used as an alternative for teachers in efforts to improve students' 21st-century skills, one of which is students' critical thinking (Permana et al., 2021) so that it should be able to influence students' collaboration skills considering that in this model group activities that the features will greatly help in e-learning are needed. This is in line with the needs analysis conducted showing 100% of students think that there is a need to implement STEM-based e-learning for physics learning, even 78.6% of students feel that using e-learning at STEM-Based Sound-wave materials has the potential to improve their collaboration skills. So, based on the explanation above, the researcher sees that there is a need for research related to the effectiveness of using e-learning at STEM-Based Sound-wave materials in improving the collaboration skills of high school students.

METHOD

This research is a pre-experimental study with a one-group t-test design, namely experimental research with one experimental class without a control class. The sample selection is made randomly. The subjects of this study consisted of 30 students in class XI SMAN 2 Palembang that selected with purposive sampling techniques.

This research was conducted in May 2022 and is part of the development research that researchers did. The stages of this research began with conducting initial observations before giving treatment by three observers from the Master of Physics Education Sriwijaya University as a pretest of student collaboration skills, then continued with the sound wave e-learning trial process based on STEM that had been developed previously, and ended with observation as a posttest of students' collaboration skills.

The learning process in e-learning is compiled according to collaboration skill indicators by Trilling & Fadel (2009),

namely: a) Demonstrate the ability to work effectively and respect team diversity; b) Demonstrate flexibility and willingness to accept the opinions of others in achieving common goals; c) Take joint responsibility in collaborative work and appreciate the contribution of each team member. So the activities and/or attitudes shown by students are expected to follow the adjustment of collaborations skills aspects in the rubric by Hermawan et al. (2017). The details can be seen in Table 1.

Table 1 Matrix of Relationship Collaboration Skills Indicators, Student Activity as an Aspect of Observation, and Position in E-learning

Indicator	Students Activity	Position in E-learning
Demonstrate the ability to work effectively and respect team diversity	Building good cooperation, cohesion, and communication between groups in conducting experimental activities as a form of good contribution in the group to solve problems provided with the effective investigation to achieve targeted and timely learning goals.	Students' worksheets
Demonstrate flexibility and willingness to accept the opinions of others in achieving common goals	Express opinions about the problems given along with explanations based on the exploration of relevant material as a form of contribution in the group, as well as respond to the opinions of other group friends to achieve the objectives of learning together on time.	Group discussion column
Take joint responsibility in collaborative work and appreciate the contribution of each team member	Cooperate with high responsibility in combining ideas and ideas from each group member to produce products that match the learning objectives on time.	The project of creating simple speakers

The learning process with e-learning is carried out by students starting with orientation, motivation, and appreciation and filling out the attendance list at each meeting. Then students can enter into a material column containing sub-materials of sound wave learning, which consists of the classification and characteristics of sound waves, sound resonance, sound intensity, interference, drifting, and doppler effects, and then a simple speaker creation project. Indicators of reference collaboration used in structuring learning in e-learning appear and can be emphasized at the discussion stage with the focus on indicators showing flexibility and willingness to accept the opinions of others; at the worksheet stage, students with a focus on indicators showing the ability to work effectively and appreciate the diversity of the team, and on simple

speaker creation projects with a focus indicator of carrying out shared responsibility in collaborative work and appreciate the contributions of each team member. The focus of the indicators determined on certain parts of each lesson is intended so that students can show attitudes expected to be observed to measure student collaboration skills according to a predetermined rubric.

The rubric of collaboration skills used as a pre and posttest observation was developed by Hermawan et al. (2017) based on the modification of a standard collaborations skills rubric by Read Write Think (2005). There are five aspects in the collaboration skills observation rubric, namely (a) Contribution; (b) Time Management; (c) Solution to a problem; (d) Working with other people; (e) Identification Techniques. Each aspect consists of four scores with a score selection of 1 for the never-criteria criterion, 2 for the infrequent criterion (only 1 time), 3 for the frequent criterion (only 2 times), and 4 for the very frequent (more than 2 times). Each criterion was adjusted to the aspect to be assessed.

The three observers were tasked with observing and assessing students' collaboration skills before using e-learning while still learning with their class teacher on mechanical wave material, as well as observing student collaboration skills after learning using STEM-based sound wave e-learning that has been developed to measure the effectiveness of STEM-based sound wave e-learning that has been developed to improve students' collaboration skills based on predefined rubrics. The pretest observation was carried out by observing each small group of students previously formed with the conventional learning given by the class teacher concerned. Two observers are responsible for two small groups, while one observer is responsible for one other group. During learning using sound wave e-learning that has been developed, the three observers are still responsible for observing the same group by observing student activities online and offline. Then, pretest observations were carried out after learning using the sound wave e-learning developed. So that the percentage score of students' collaboration skills is obtained before and after using e-learning with the percentage calculation formula as follows:

$$\%CS = \frac{score\ obtained}{maximal\ score} \times 100 \quad \ldots\ldots(1)$$

%CS: Collaboration Skill Aspect Score Percentage

Measurement effectiveness of using e-learning at STEM-Based Sound-wave materials in an effort to improve student collaboration skills is carried out by calculating N-Gain. In addition to using the N-Gain calculation, the determination of effectiveness by statistical testing takes into account: (1) conducting parametric statistical tests (two-sided t-test with = 0.05 because they want to know whether there is a difference between the pretest and posttest results) if the data is normally distributed; or (2) using a non-parametric statistical test (Wilcoxon test) if the data are not normally distributed using the SPSS v.24. application based on Kolmogorov-Smirnov normality criteria. The determination of effectiveness by measuring N-Gain refers to Table 2.

Table 2 Effectiveness Level Based on N-Gain(Hake, 1998)

N-Gain Value Criteria	Category
N gain≥0.7	High
0.7> Ngain≥0.3	Medium
N gain<0.3	Low

The hypotheses developed in this study include the following:

H_0 = there is no significant difference before and after using e-learning at STEM-Based Sound-wave materials to improve the collaboration skills of high school students

H_1 = there is a significant difference before and after using e-learning at STEM-Based Sound-wave materials to improve the collaboration skills of high school students.

RESULT AND DISCUSSION

Observations of student collaboration skills carried out by three observers resulted in the average percentage of students' initial collaboration skills before treatment (pretest) and student collaboration skills after being given treatment (posttest) can be seen in Table 3.

Table 3 Statistical Analysis of Student Collaboration Skills

Aspect	Pre	Post	N-Gain
N (Number of Students)		**30**	
Average	11	17.13	0.68
Standard Deviation	1.259	1.252	
Normality test (α = 0.05) data	0.071 (Normal)	0.062 (Normal)	
T-test (α = 0.025)	t_{count} = 30,377 Level of significance (p) = 0.000 (significant)		

Based on Table 3, the data obtained before and after treatment for 30 samples of students were normally distributed with an increase in the average score of collaboration skills from 11 before treatment to 17.13 after treatment, so the average N-Gain value was obtained. Students' collaboration skills are 0.68 in the medium category, or in other words, the e-learning at STEM-Based Sound-wave materials that have been developed as a whole is quite effective in improving students' collaboration skills. The t-test performed resulted in the t_{count} data of 30.377.

Because we want to know the difference between before and after treatment (it can increase or decrease), a two-sided t-test is carried out with 0.025 so that $_{table}$ = 2.0484. Based on this description, it can be concluded that H_0 is rejected or in other words, there is a significant increase in students' collaboration skills after being given treatment in the form of using e-learning at STEM-Based Sound-wave materials. The details of improving students' collaboration skills in each aspect and its N-Gain are shown in Table 4, and Figure 1.

Table 4 Collaboration Skills Before Treatment, After Treatment, and N-Gain of Each Indicator

No.	Indicators/Aspects	N	Percentage		N-Gain
			Pre	Post	
1	Contribution	**30**	56,67	93,33	0.85
2	Time Management		45,00	80,00	0.64

3	Solution to problem		49,17	82,50	0.66
4	Working with other people		78,33	91,67	0.62
5	Identification Techniques		45,83	80,83	0.65

Based on Table 4, there is an average increase in collaboration skills for all indicators. The first indicator, namely the contribution, increased by 36,67% with an N-Gain of 0.85, entering the high effectiveness category. The second indicator, time management, has increased by 35% with an N-Gain value of 0.64 in the medium category. The third indicator, problem-solving, has increased by 33,33% with an N-Gain of 0.66 in the medium category. Following previous research. The fourth indicator, working with others, increased by 13,33% with an N-Gain of 0.62 in the medium category. The fifth indicator, the investigation technique, increased by an average of 35% with an N-Gain value of 0.65 in the medium category.

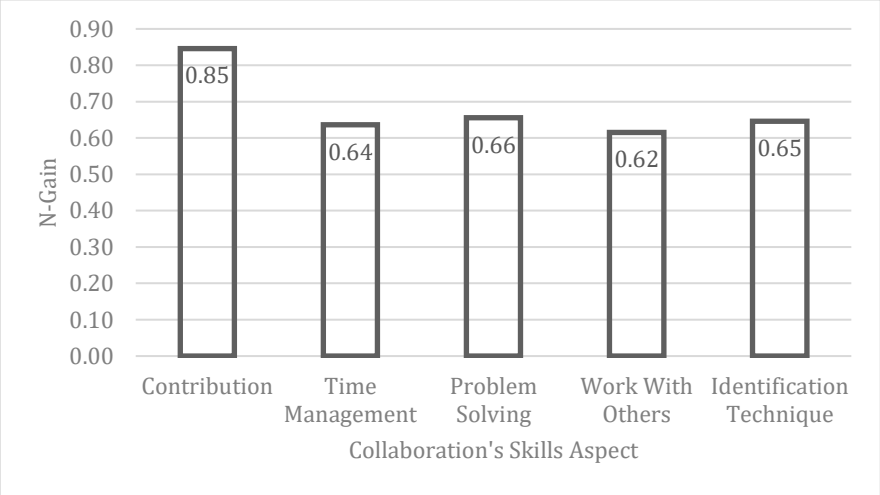

Figure 1 Collaboration Skills Improvement Graph

Based on Figure 1, it can be seen that the highest increase was 0.85 in the first indicator, namely contribution, while the lowest increase was 0.62 in the fourth indicator, namely working with other people. This corresponds to the phase of adolescent psychological development, in this case, high school students who tend to force things according to what they expect/want (Ajhuri & KF, 2019). So when faced with situations that require working in groups, they will also prefer to be heard/express opinions compared to listening to the opinions of others even though their ability to be a listener is quite good compared to their ability to provide ideas even when they are not working in a group.

This is also possible because the e-learning at STEM-Based Sound-wave materials is designed with a discussion forum that dominates compared to practicum and/or project activities so that the opportunities for students to give opinions are much greater than listening to other people's opinions. That way, it can strengthen that an important component in e-learning is one of the very dominant factors in improving student collaboration skills, including learning activities, carried out through the utilization of the network ("network" in this description is limited to internet use, may include LAN and WAN), the availability of support for learning

services that can be used by students, such as CD-ROMs, or printed materials, and the availability of tutor service support that can help students learn when experiencing difficulties, the design of a learning system that can be studied/known by each learner, an evaluation system of the progress or development of learning of the learner; and feedback mechanisms developed by the administering agency (Khatimi, 2006). Moodle is a learning management system (LMS) which has very useful for adding a pattern of interactive course material such as group chat, forums, individual and group projects, surveys on a particular subject, etc. These materials enable students to collaborate and share with their teachers to build and learn content (Carvalho et al., 2013).

Thus, based on all the data obtained, STEM-based sound wave e-learning that has been developed can be declared effective in improving the collaboration skills of high school students in the medium effectiveness category. These results follow previous research with results showing that interactive multimedia, including e-learning, is effective in the N-Gain medium category for physics learning (Wiyono et al., 2020), the application of STEM-based physics learning can improve students' collaboration skills (Cholis & Yulianti, 2020), and integration between project-based learning models and learning with an e-learning-based STEM approach to science learning is believed to improve the achievement of learning objectives (Rochim et al., 2021).

CONCLUSION

E-learning at STEM-Based Sound-wave materials that have been developed previously obtain an average N-Gain score of 0.68 in the medium category. The highest increase occurred for the contribution aspect, with an N-Gain score of 0.85 in the high category. In contrast, the lowest increase occurred in working with others, with an N-Gain score of 0.62 in the medium category. This is in line with the psychological development of high school-age adolescents, who desire to be heard compared to listening. Based on these results, the e-learning at STEM-Based Sound-wave materials that have been successfully developed is quite effective in improving the collaboration skills of high school students.

ACKNOWLEDGEMENT

DIPA of the Public Service Agency of Universitas Sriwijaya 2022 funded the research publication of this article. SP DIPA-023.17.2.677515/2022. On December 13. 2021. Following the Dean's Decree Number: 1439 / UN9. FKIP / TU. SK / 2022. On May 20, 2022.

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