Online Learning Using STEM-Based Media: To Improve Mathematics Abilities of Vocational High School Students

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Online learning recently is alternative learning at all levels of education. Online learning in mathematics can be done synchronously or asynchronously, such as using zoom or e-learning. However, online learning is still ineffective in improving students' abilities because of its limitations, especially in high-level skills such as mathematical abilities. This study aims to use online learning with STEM-based media to reveal the mathematical skills of vocational high school students. This research method is a quantitative study with a quasi-experimental design, with two sample groups, namely the experimental group and the control group. The subjects of this study were 120 students of vocational high school. The results showed that STEM-based media could improve the mathematics abilities of vocational high school students seen from the whole student or based on the level of group students. Likewise, positive student responses to online learning using STEM-based media. This response means that students feel the benefits of learning online using STEM-based media.

Keywords: online learning, vocational high school, mathematics abilities, STEM-Based media, student's responses

INTRODUCTION

Online learning was implemented several years ago. One pattern of online learning is through the Distance Learning (DL) program, where the learning process is carried out between students and separate educators. It places more emphasis on independent learning (Yuangga, K., & Sunarsi, D., 2020). Even DL has long been implemented in developed countries. Based on data obtained from UNESCO in 1989, DL was implemented in the United States in 1892, Australia and New Zealand at the beginning of 1922, while in England in 1966 and is considered the most prosperous country in implementing DL (Indriani, T. M., Fathoni, T., & Riyana, C., 2018). DL is applied in

developed countries, meaning that DL has been recognized by various countries and can be applied to overcome multiple educational problems.

Online learning still has some drawbacks on the student's side, including difficulty in internet connection, cannot discuss directly, students feel tired of being in front of a laptop or cellphone continuously, and they find it difficult to divide study time and self-discipline while at home (Pujiasih, E., 2020). This factor causes the low ability of students, especially for practice-based subjects that require mathematics abilities. Online learning also has weaknesses when teachers find it difficult to train psychomotor skills, although face-to-face learning still has weaknesses, including limited space and time (Azhari & Fajri, 2021). During the learning process, students need feedback from the teacher and vice versa. The teacher also needs feedback from their students. In this way, more effective and targeted learning outcomes will be obtained (Indriani, T. M., Fathoni, T., & Riyana, C., 2018).

Science, Technology, Engineering, and Mathematics (STEM) is one of the developments in education (Menglin, F., et.all., 2021). The STEM approach is formed based on combining several disciplines that are combined into a new and unified form of course. The fields that form the basis of the STEM approach are science, technology, engineering, and mathematics (Alabdulhadi, A., Faisal, M., 2021). Integrating these several disciplines into one unit is expected to produce competent and quality graduates, not only in terms of mastery of concepts but also in applying them to life. The STEM approach combines science, technology, engineering, and mathematics into one overall curriculum (English, L. D., & King, D., 2019).

One effort that can be made to minimize the shortcomings of online learning, especially in achieving mathematics ability, is to develop media based on STEM. This development is expected to complement each other between the shortcomings of online learning and face-to-face learning (Sırakaya, M., Alsancak Sırakaya, D., 2020). The use of media is expected to improve students' ability in online learning. STEM is believed not only to provide opportunities for students to have the ability of understanding science, technology, and engineering according to current developments, but it can also train students' mathematical abilities. STEM-based media was used in this study to explain technical problems in vocational high school students. STEM-based media is used in this research because vocational education requires students to be able to use science, technology, engineering, and mathematics in real contexts that connect schools, the world of work, and the global world so that students are enabled to compete in the 21st century. STEM-based media is expected to be able to solve the problems of everyday life by applying it in schools whose subjects are studied by combining the knowledge, skills, and attitudes possessed by students. In addition, STEM learning can also prepare students to be more qualified to compete and be ready to work in the fields they are engaged in.

The problem in learning mathematics in vocational education is that there are still many students who find it difficult to understand the application of mathematics in engineering. It is challenging to make mathematical modeling, although the nature of

modeling as a mathematical practice is essential to the transition phase for students of engineering problems (Wake, G., 2016), so it is necessary to integrate technology, engineering, mathematics, and science in their learning. Therefore, the purpose of this study was to determine: 1) STEM-based media is used in learning, 2) How the mathematical abilities of vocational high school students who learn using STEM-based media and those who just by online learning, 3) Whether there are differences in mathematical abilities between students who learn the use STEM-based media and those who just by online learning, 4) how are students' responses to the use of media based on STEM.

Literature Review

Learning Media

Learning media plays an essential role in directing the process and the desired results of learning. The advantages of teaching assisted by media have the following benefits: 1) it can provide a deeper understanding of the learning material being discussed. 2) Can explain learning materials or objects that are abstract. 3) Helping teacher's present learning material more easily and quickly. 4) Attract and arouse students' attention, interest, motivation, activity, and creativity (Munir, 2015). Learning media have used, namely: clarifying the presentation of the message so that it is not too verbalistise. Overcome the limitations of space, time, and senses. The use of appropriate and varied media can overcome the passive attitude of students (Sadiman, et al., 2012:17).

The current learning system requires students to act as the recipient of the material and act as a communicator or conveyors of the material resulting in two-way communication and even many-way communication (Nurseto, 2011). In learning communication, learning media is needed to improve the effectiveness of learning achievement goals. The learning process will occur if there is communication between the recipient of the message and the source/channel message through the media. This is in line with the meaning of learning media is a tool that serves to convey the message of learning (Mediawati, 2011), So that the learning by using media becomes more effective (Bulut, Akçakın, Kaya, & Akçakın, 2014; Wibowo, 2013; Ismail, Sugiman and Hendikawati, 2013; Susilana, R., Rullyana, G., Ardiansah., & Wulandari, Y., 2022). Therefore, the learning media as part of the learning system has a role in improving student learning outcomes and teacher factors, teaching materials, methods, and so on.

Science, Technology, Engineering, and Mathematics (STEM)

Science, technology, engineering, and mathematics (STEM) is an effective model for implementing integrative thematic learning because it combines four primary areas of education, namely: science, technology, mathematics, and engineering. This approach is a match between problems that occur in the real world and problem-based learning because it is essential to combine technology with integrated STEM education and learn to use it to support student learning and solve educational problems (Yang, D., Baldwin, S.J., 2020),

STEM abilities are very important so that students know that the education they take is helpful in solving problems and situations in the real world. The problem-solving process based on student design is expected to be able to overcome real-world situations (Anggraini, F. I., & Huzaifah, S., 2017). STEM integration will be more effective if it uses a strategic approach and effective media in its implementation so that it can make students learn more relevant, stimulate the emergence of meaningful experiences, encourage students to think at higher levels, solve problems and increase retention. STEM building a strategic approach to acquiring STEM skills requires a conceptual understanding and a solid foundation of how students learn and implement STEM (Kelley, T. R., & Knowles, J. G., 2016).

The purpose of STEM-based learning on media is to improve students' skills in four fields of science, namely science skills, technology operating skills, problem-solving techniques, and mathematical skills. There are very suitable to be applied to face the challenges of the 21st century (Rifandi, R., & Rahmi, Y. L. (2019).

Many kinds of STEM research have been carried out, including STEM learning has succeeded in changing the teaching model to emphasize innovation and problem solving (Corlu, M. S., Capraro, R. M., & Capraro, M. M., 2014). STEM learning becomes a learning innovation to build 21st century skills (Permanasari, (2016), STEM improves students' scientific literacy (Afriana, Permanasari, & Fitriani, 2016), STEM can improve students' creative thinking skills (Ismayani, 2016), STEM can increase students' creativity (Lou, Chou, Shih, & Chung, 2017), STEM can improve students' high-level creative thinking skills (Kristiani, Mayasari, & Kurniadi, 2017), STEM learning makes students have significantly better multi-presentation skills (Thibaut, Ceuppens, et al., 2018), PjBeL-STEAM learning model improves students' mastery of ecological concepts (Sigit, D. V., Ristanto, R. H., & Mufida, S. N., 2022). Based on research on STEM shows that STEM-based learning has the potential to improve student's abilities

STEM-based media in research are learning media whose material is presented in the form of animation, elevating the processes of science, technology, engineering, and explained in the animation of the mathematical modeling process. So the STEM step is carried out in each material. For example, in the material on the concept of electronics to calculate electrical resistance, DC circuits, basic laboratory capacities. In addition, there are brake lining thinning materials, a temperature drop of the heated workpiece, and other materials. All materials are presented in a sequence of STEM learning steps involving aspects of science, technology, engineering, and mathematics. Aspects of science, namely the material presented, follow the field of science, for example, in the field of electricity. Technological aspects, such as electrical circuit technology. Technological aspects, such as vehicle braking technology. Aspects of mathematics, for example, train to have mathematical abilities, including performing technical calculations to complete concepts.

METHOD

This study is a quantitative study by a quasi-experimental design, with two sample groups, namely the experimental group and the control group. Each group after learning

is given a final test. This final test is to determine the difference in mathematical ability after the learning process using STEM-based media in the two groups is carried out. The experimental group was given online learning treatment with STEM-based media and the control group was given regular online learning. The research design used is:

X1   O
X2   O
Note:
O: Final test of mathematical ability
X1: learning mathematics with STEM-based media
X2: Learning mathematics online

The design (X1 O) means that students learn online by using STEM-based media, then ends with a final test, and (X2 O) means that students learn online without using STEM-based media, then ends with a final test. The data revealed in this study was used to test and non-test instruments. The non-test instrument uses a questionnaire. The instrument is used to test media while determining the increase in STEM ability using pre-test and post-test instruments. Data collection techniques from each instrument in the study will be described as follows: final test aiming to determine the improvement of students' mathematics abilities.

The population of this research is vocational high school students, while the samples are students of class XI of the school. Samples were taken by cluster random sampling, as many as 2 classes. One class was an experiment in implementing online learning with STEM-based media, the other class was with regular online learning. Both online learning also uses the e-learning system in the school.

The number of each sample member is 120 students, with details of 60 students for the class who learning mathematics with STEM-based media and 60 other students for the control class who Learning mathematics online only. Students are grouped based on previous mathematical abilities, into three, namely the upper, middle, and lower groups. The complete group division is shown in Table 1.

Table 1
Student group divide interval

Interval			Group of student
80,2	<score ≤	91,9	: upper
68,5	< score ≤	80,2	: middle
56,6	<score ≤	68,5	: lower

Based on Table 1, out of 120 students, they were divided into 30 students belonging to the upper group, 60 students from the middle group, and 30 students from the lower group. Furthermore, of the 30 upper group students, 15 students included online classes with STEM-based media and 15 students whose learning was only online. Then from 60 middle group students, 30 students in online classes with STEM-based media, and 30 students in regular online classes. and from 30 students in the lower group, 15 students

enter the class with online learning with STEM-based media and 15 students who learn online. In detail, the distribution of the sample in this study is shown in Figure 1.
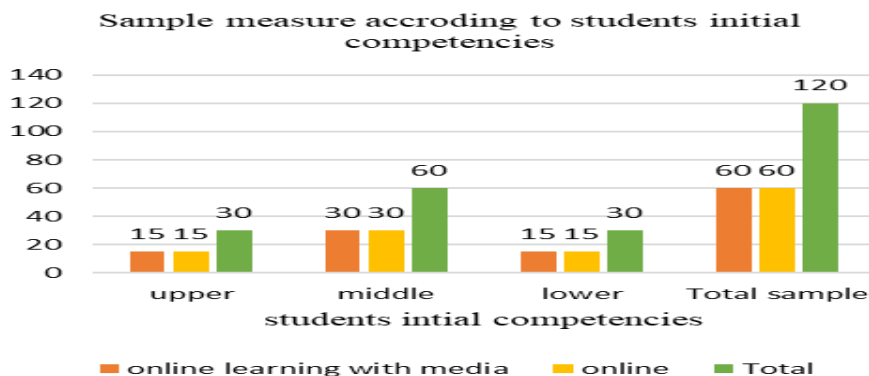

Figure 1
Sample measure

Students' mathematical abilities were assessed through tests, while students' responses to the use of STEM-based media were based on an attitude scale. The data were processed using Microsoft Excel 2010. Before testing the hypothesis, the statistical requirements were first checked, namely the normality test for the distribution of the research subject data for each group. Then test the homogeneity of variance between the groups. Statistical rules to test the hypothesis, using two-way ANOVA and Scheffe test. The use of this analysis is intended to examine the difference in mathematical ability in the form of the mean between online classes with STEM-based media and ordinary online classes, according to the division of student groups.

Analysis of variance/ANOVA was carried out on the final test results to see the difference between groups of online class students with STEM media and online classes only, both viewed as a whole, and based on the group (upper, middle, and lower).

Furthermore, to facilitate the calculation of both the average analysis, standard deviation, t-test, Scheffe test, and analysis of variance, SPSS version 21 for Windows was used, namely the General Linear Model Univariate (GLM) procedure.

The hypothesis testing criteria for the normality test is to accept the hypothesis if the significance (p-value) is greater than the significance level used, for example, 5%. Likewise, the homogeneity test, t-test, Scheffe test, and ANOVA accept the hypothesis if the significance (p-value) is less than the 5% significance level.

Questionnaires use for students' responses who implement STEM-based media. The questionnaire was developed using a Likert scale with 4 options, namely: Strongly Agree (SS), Agree (S), Disagree (TS), and Strongly Disagree (STS). After collecting data, simple statistical data processing was carried out to determine the improvement of students' mathematics abilities after the teaching and learning process with innovative multimedia.

The results of the questionnaire were processed based on the percentage of the overall score on the attitude scale. The assessment criteria for the percentage of attitude scale questionnaire results follow the following provisions as in Table 2:

Table 2
Student group divide interval (Natsir, 2002)

Interval	:	criteria
0 % ≤ percentage ≤ 20%	:	very less positive
20% < percentage ≤ 40%	:	less positive
40% < percentage ≤ 70%	:	quite positive
70% < percentage ≤ 90%	:	Positive
90% <percentage ≤ 100%	:	very positive

The questionnaire is a data collection technique that is done by giving a set of questions or written statements to respondents to answer. Questionnaires are an efficient data collection technique if the researcher knows with certainty the variables to be measured and knows what to expect from the respondents. The distribution of questionnaires to students was carried out so that researchers could obtain an overview of student responses to the treatment given by researchers using animated media. The questionnaire consists of 15 indicators. To ensure that the questionnaire was used in capturing student responses, the questionnaire was tested for validity and reliability. Then the instrument validity test, instrument reliability test, and feasibility test will be carried out. The validity of the items is sought by using the correlation formula. All statements on the questionnaire are valid so the 15 items can be used to determine student responses. Reliability testing using internal testing with the Cronbach Alpha formula obtained 0.89. This value means that the interpretation of the reliability instrument is in the high category. The formula is used to calculate the percentage of the questionnaire as in equation (1).

$$P = \frac{f}{n} \times 100\% \tag{1}$$

Note: P = percentage of answers; f = frequency of answers; n = number of respondents

The hypotheses that will be proven in this study are: 1) There are differences in students' mathematical abilities with online learning using STEM-based media and ordinary online learning. 2) Student responses to online learning using STEM-based media are more positive than students' attitudes to online learning alone. Research Result and Discussion.

FINDINGS

The problem that occurs in learning mathematics in vocational schools in which the solution will be found is that there are still many students who have difficulty understanding the application of mathematics in engineering, it is difficult to make mathematical modeling of engineering problems, so it is necessary to integrate technology, engineering, mathematics and science in their learning. The integration of technology, engineering, mathematics, and science in this research is carried out through

STEM-based media that has been developed. The following shows the media used in this study.

STEM-Based Media

STEM-based media used in this study as in Figure 2 show the display of material choices on the. Students can choose what material to study according to their wishes. In each of the materials presented, there is an about button that describes the material and a guide button that explains the functions of tools in the media.
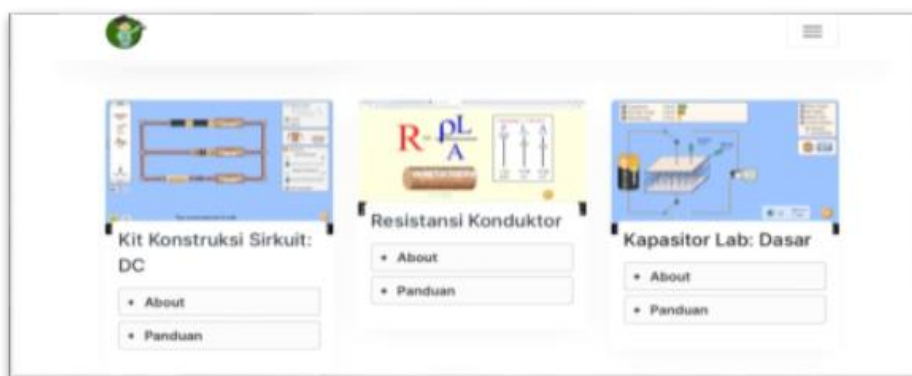

Figure 2
Display of the main menu of STEM-based media

Figure 2, is an example of the display of STEM-based media implemented in this study. This media contains learning materials that students can choose from. The material offered is about the concept of electronics to calculate electrical resistance, DC circuits, and basic laboratory capacities. In addition, there are materials on the thinning of the brake pads, the decrease in the temperature of the heated workpiece, and other materials. All materials are presented in the order of STEM learning steps, which involve aspects of science, technology, engineering, and mathematics. Aspects of science, namely the material are presented following the field of science for example in the field of electricity. Technological aspects, such as electrical circuit technology. Technological aspects, such as vehicle braking technology. Aspects of mathematics, for example, training students to have mathematical abilities, including performing technical calculations to complete the concept.

Students Mathematics Abilities

The final test results of students' mathematical abilities are described based on the learning model and student groups. These results explain the descriptive data viewed as a whole, namely from the applied learning (online with STEM-based media and online only) and based on student groups (upper, middle, and lower). The complete descriptive statistical data is presented in Table 3.

Table 3
The results of the final test of students' mathematical abilities

students group	learning type	Mean	Std. Deviation
Lower	Online	65.55	11.67
	Online with media	68.77	11.083
	Total	67.16	11.29
Middle	Online	68.56	7.452
	Online with media	71.17	7.949
	Total	69.86	7.752
Upper	Online	77.78	7.76
	Online with media	76.18	7.94
	Total	76.98	7.76
Total	Online	70.11	9.77
	Online with media	71.82	9.09
	Total	70.97	9.43

The final test of mathematical ability is carried out after all the learning processes in the research have been completed. The test is in the form of a description to evaluate the mathematical ability of all learning materials that have been given. Based on Table 3, seen from all students based on learning (online with media and online only) it was obtained that the mathematical ability for all students, the average through ordinary online learning was 70.11 with a standard deviation of 9.77, while for online classes with media Based on STEM the average is 71.82 with a standard deviation of 9.09. These results indicate that for all students, the average mathematical ability of students online using STEM-based media is slightly better than the average online mathematical ability of students. The standard deviation through online learning is greater than the standard deviation through online with STEM-based media. This means that the spread of students' mathematical abilities by online learning is greater than the spread of students' mathematical abilities by online learning using STEM-based media. Likewise, if based on the initial ability group of students, **it can be seen** that the average mathematical ability of lower group students through online learning with media is slightly better than ordinary online ones. Likewise, for students with middle initial abilities, the average mathematical ability of students through online with STEM-based media is better than online-only, while for students with upper initial abilities, it is through online learning that it is greater than students through online learning with media.

Furthermore, before discussing further the results of the final mathematical ability test, first, a normality test was carried out on students through online learning with media and ordinary online learning using the Kolmogorov-Smirnov[a] and Shapiro-Wilk-tests as are shown in Table 4.

Table 4
Normality test of students' mathematical ability results

	students group	Kolmogorov-Smirnov[a]	Shapiro-Wilk
		Sig.	Sig.
mathematics abilities	Lower	.200*	.225
	Middle	.200*	.198
	Upper	.097	.201

From Table 4, it can be seen that the significance value (p-value) for the three data distributions is greater than the 5% significance level. This indicates that the three classes have a normal distribution. Likewise, the homogeneity test obtained is presented in Table 5.

Table 5
Homogeneity test of students' mathematical ability variance

F	df1	df2	Sig.
1.801	5	114	.118

Based on the variance test on students' mathematical abilities as shown in Table 5, it was found that the three variances were homogeneous. This is indicated by the results of the Levene test with a significance value (p-value) of 0.118 which is greater than 5%.

Furthermore, the test of the average difference in mathematical ability was reviewed based on the students' initial abilities and the learning model used was tested with the 2-way ANOVA statistical test as shown in Table 6.

Table 6
ANOVA final test results of students' mathematical abilities

Tests of Between-Subjects Effects		
Dependent Variable: mathematics abilities		
Source	F	Sig.
Corrected Model	4.64	.001
Intercept	7122.87	.000
Groups	10.32	.000
Learningmodel	9.69	.026
groups * learningmodel	.72	.488
a. R Squared = .169 (Adjusted R Squared = .133)		

Table 6 shows the results of data analysis using ANOVA to find out whether there are differences in students' mathematical abilities, both in terms of student's initial abilities and from the methods used, namely: online with STEM-based media and regularly online. Based on the analysis of variance on the mathematical ability test in Table 6, the significance value (p-value) for the group factor (group of students' initial abilities: upper, middle, and lower) was 0.00, because the sig was smaller than 5%, then the null hypothesis is rejected. This means that there are differences in the mathematical ability of students seen based on their initial ability groups or mathematical abilities based on students' initial abilities, namely students with upper, medium, and lower abilities

through online learning with STEM-based media are significantly different from ordinary online ones. Thus the hypothesis states that "There are differences in students' mathematical abilities with online learning using STEM-based media and ordinary online learning in terms of student groups is accepted. That is, if the three results of mathematical ability are compared together, it shows that there is a significant difference. Likewise, for the learning model factor used, it was obtained as significant = 0.00 which is less than 005. This means that there are differences in students' mathematical abilities seen from the learning model used. That the online learning model with media and ordinary media provides differences in learning outcomes for the three groups of student's initial abilities.

However, if a follow-up test with the Scheffe test is carried out for the three learning groups, it will be known that there is a difference for any group of students. Table 7 displays the results of the Scheffe test as follows:

Table 7
Scheffe test for students' mathematical ability results based on   applied learning

(I) students group	(J) students group	Sig.
Lower	Middle	.172
	Upper	.000
Middle	Lower	.172
	Upper	.000
Upper	Lower	.000
	Middle	.000

From the results of the Scheffe test in Table 7, it is found that the hypothesis which reads "Mathematical abilities based on students' initial ability groups via online with different media from online-only", is accepted. This means that the mathematical ability of the lower and middle group students who study online using media is different from that of the upper group students.

The mathematical ability of middle group students who study online with STEM-based media is different from upper group students. However, the mathematical ability of the lower group students was not different from that of the middle group students. This means that the hypothesis: "The mathematical ability of students who study online with STEM-based media is different for students in the lower and middle groups and students in the upper group". Next, a picture of the average difference between the groups is presented as shown in Figure 3.
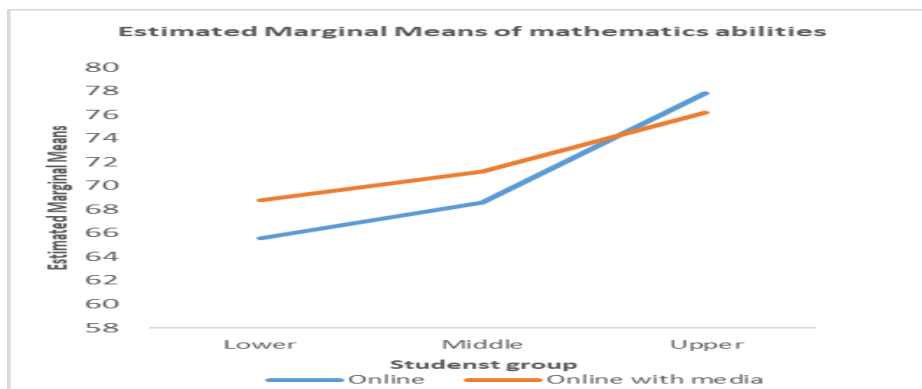
Figure 3
Interaction of students' mathematical abilities based on learning models and groups of students' initial abilities

Figure 3, is the interaction between students' mathematical abilities through online learning with STEM-based media and online-only. The mathematical ability of students for the lower and middle groups through online learning with media is upper than in ordinary online learning. Meanwhile, for students in the upper group, it is better for students through ordinary online learning than online with STEM-based media.

Online learning with STEM-based media is considered suitable to be used to improve the mathematical abilities of students in the lower and middle groups, while for students in the upper group it is suitable only with ordinary online learning.

From Figure 3, it can be seen that the mathematical ability of upper-group students through regular online learning shows a better value than the mathematical abilities of upper-group students through online STEM-based media. The mathematical ability of middle and lower group students through online learning with STEM-based media is better than ordinary online learning. So there is an interaction between online learning with STEM-based media and regular online for the three students' abilities to their mathematical abilities significantly.

The results of data analysis both from the 2-way ANOVA, as well as from the follow-up test and plot diagrams, the results show that the use of STEM-based media in online learning generally provides better mathematical abilities than online ones without media. This means that STEM-based media as digital content can improve student learning outcomes (Fatchurahman, Adella, & Setiawan, 2022); Lukitasari, M., Murtafiah, W., Ramdiah, S., Hasan, R., & Sukri, A. (2022).

STEM-based media can convey messages and can stimulate students' thoughts, feelings, and willingness to learn (Sudrajat, 2008). Based on this, STEM-based media can be used by teachers to send messages to students. STEM-based media makes learning situations more effective, interconnected with other components so that the learning situation is as expected, abstract concepts become more concrete, verbalism is reduced, increases student learning stimulation, reduces student misunderstandings about the

explanations given by educators, overcomes the limitations of the student experience, direct interaction between students and the environment, lead to uniformity of observations, and generate motivation and stimulate children to learn (Nurseto, 2011; Sudrajat, 2008).

Students' Response to The Use of STEM-Based Media

The implementation of learning was carried out on 60 vocational high school students who learning mathematics using STEM-based media. Furthermore, to determine student responses to online learning using STEM-based media according to students' questionnaires results are shown in Figure 4.
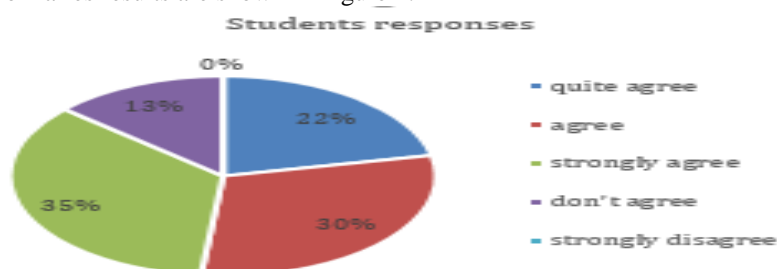

Figure 4
Student response results

Figure 4 shows that the percentage of students who answered the category strongly disagree with the use of media was 0%, don't agree with the percentage of 13%, quite agree with the percentage of 22%, agree with the percentage of 30%, and strongly agree with the percentage of 35%. Because more than 70% of students agreed with the use of STEM-based media in online learning, Based on Tabel 2, it can be concluded that STEM-based media according to student responses is generally positively accepted as a medium that can help students to learn mathematics in vocational education.

Student responses are based on cognitive dimensions related to students' knowledge and understanding of the use of learning media. The cognitive dimension consists of indicators of understanding STEM media content, clarity of learning instructions and information, and appropriateness of STEM media display.

In general, based on the results of descriptive analysis after learning by applying media, obtained a greater ability than before applying media. The average obtained from the descriptive analysis can be used as a reference for knowing the differences before and after using the media.

The learning process using STEM-based media makes students better understand the material being taught. In the learning process, students can see and listen more seriously related to the concepts being taught and can see its components virtually. The existence of animation in media that can be used is very helpful in improving a more effective learning experience. In this activity, students learning online with STEM-based media were given a post-test with an average score better than online only. That is, there is an increase after the use of media. This is following the statement of (Habibbulloh, M.,

Jatmiko, B., & Widodo, W., 2017) that learning with media is more efficient because the processing of learning with virtual labs is carried out faster than learning with conventional methods, besides that student responses to the use of STEM-based media are also very positive. This is in line with research from (Winarni, Zubaidah, and Supriono, 2016) that STEM can increase creativity and competitiveness. The effectiveness of learning using STEM-based media can be seen from the increase in students' scientific literacy, meaning that the virtual laboratory can be said to be effectively used in learning if there is an increase in students' scientific literacy (Barakos, 2012).

CONCLUSION

Based on the results of the study, it was concluded as follows: the mathematical ability of upper vocational high school students was better in lower and middle group students. Student responses to STEM-based media are also positive. the use of STEM-based media in online learning provides better mathematical abilities than online without using media, so it can be concluded that learning with STEM-based media is effective in improving students' mathematics abilities. Based on the research conducted, STEM has been successfully applied to mathematics. Thus, further research on STEM-based learning can be applied to technical vocational learning that requires practice and problem solving related to daily activities.

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