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STEM Integrated Flipped Classroom Learning Tools on Biodiversity Materials to Improve Students' Critical Thinking Skills

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Article Info

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Abstract

Thinking skills of students in Indonesia are still in the low category. This is evidenced by the results of Indonesia's PISA score which is still far from the international score. The COVID-19 pandemic has forced learning to be done online at home. So in this case it is necessary to update the learning model that is applied. This study aims to produce learning tools that can be used to improve students' critical thinking skills during the COVID-19 pandemic. The method used is Research and Development which consists of 10 stages of research. This research was conducted in the odd semester of the 2021/2022 academic year in class X MIPA 1 SMA N 1 Pagelaran. The sampling technique used is probability with the type of simple random sampling. Data collection was done by using questionnaires, tests, and interviews. The learning device developed using the flipped classroom model which is integrated with STEM to improve students' critical thinking skills during the COVID-19 pandemic. The results showed that the learning tools developed, including the syllabus, lesson plans, worksheets, and evaluation tools were suitable for use in learning. The syllabus gets a feasibility percentage of 93.75% and the lesson plans get a feasibility percentage of 86.45% from learning experts. The LKS developed got a feasibility percentage of 82.50% from material experts and 93.33% from media experts. While the evaluation tool gets a percentage of 94.33% from evaluation experts. The results of the small-scale trial showed a very good response from the teacher to the experimental device developed, with an average percentage of 95.31% for the syllabus, lesson plans of 94.79% and LKS of 95.00%. The LKS developed got a very good response from students with a percentage of 90.10% and produced 30 items that were worthy as an evaluation tool. The results of the trial using the evaluation tool using the paired sample test obtained a value of Sig (2-tailed) = 0.00 < (0.05) which means that there is a significant influence on the application of STEM-integrated flipped classroom learning tools with students' critical thinking skills. Based on the results of the study, it can be concluded that the development of STEM-integrated flipped classroom learning tools to improve students' critical thinking skills is feasible to use in learning.

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INTRODUCTION

The development of education in the 21st century requires students to have skills in the future, one of these skills is critical thinking skills or called critical thinking. Critical thinking ability is part of cognitive skills in which there are several analysis, interpretation, evaluation, inference, explanation, and self-regulated activities (Lismaya, 2019). Critical thinking skills are needed by students to connect a concept and material in order to be able to understand and solve problems in the classroom (Beers, 2014). The critical thinking skills of students in Indonesia are still very low, this is revealed based on a survey conducted by the OECD through the TIMSS program.

Table 1 Results *Trends in International Mathematics and Science Study*

Years	Rank	Delegasi	Average score of Indonesia	Average score of Internasional
2003	35	46 Negara	411	467
2007	36	49 Negara	397	500
2011	38	42 Negara	386	500
2015	44	49 Negara	397	500

Based on the table above, it is known that the average score obtained by Indonesia is below the international average score, which means that the scientific achievements of Indonesian students are in the low category (Hadi & Novaliyosi, 2019). The low level of scientific achievement proves that Indonesian students' ability to think critically is in the low category. Hearing this gives a great responsibility for educators to be able to evaluate the learning process. One solution that can be done to overcome the problem of low critical thinking is to make improvements to the learning process. Success in the learning process can also be influenced by several factors such as the selection of appropriate models, strategies, and techniques. Mastery of critical thinking skills is influenced by the selection of learning models applied by teachers in the learning process, especially when inculcating concepts in students.

Critical thinking problems can be solved by using learning tools that encourage students to think critically. Therefore we need a learning device that can be used to overcome problems regarding students' critical thinking skills. In addition to the need for appropriate learning tools, information and communication technology is also needed to support learning in 2021/2022 to overcome problems regarding students' critical thinking skills in this COVID-19 pandemic era, namely by applying face-to-face learning online.

Online-based learning is a learning system that is carried out not face to face but uses a platform that can help the teaching and learning process that is carried out even though it is far away. In this online learning, instructions or commands are transmitted using digital information processing devices such as computers, notebooks, tablets, or smartphones that aim to provide quality services that make it easier for students to learn. Online-based learning that is applied remains focused on students (student centered learning). One of the implementations of student centered learning is to apply blended learning-based learning. Blended learning is a form of learning that combines face-to-face learning with online learning that utilizes the role of technology (Dwiyogo, 2014). In implementing blended learning-based student centered learning, an appropriate learning model is needed, one of which is the flipped classroom model.

Flipped classroom is a learning model that minimizes direct teaching, but maximizes indirect teaching with the help of applications that can be accessed online by students (Sudarmanto et al., 2021). This model has wide opportunities to train students to be active and independent in the learning process in order to improve students' critical thinking skills. In its application, the flipped classroom model can be integrated with technology to carry out online learning at home.

The flipped classroom model is very appropriate to be applied in learning to improve students' critical thinking skills during the COVID-19 pandemic, this is because this model has several advantages, namely: a) learning can be adjusted to the speed of student understanding because students can repeat the material, b) work homework is done in class so that students can ask questions about parts that have not been understood, c) students have the advantage to access learning in full, d) learning time is used effectively for discussion, e) the application of flipped classroom gets high results compared to traditional learning (Yildrim

& Kiray, 2016).

The results of a preliminary study conducted at SMA N 1 Pagelaran, found several problems that affect success in the learning process during the COVID-19 pandemic, one of which is the use of methods or models in learning. The results of the observations made can be seen that at the school the teacher has never implemented flipped classroom-based learning but has started to apply learning with a scientific approach, but more often applies conventional learning.

The students' low critical thinking skills can also be proven based on the results of interviews conducted with one of the biology teachers at SMA N 1 Pagelaran which stated that students' KKM completeness had not reached 50%, so it was still far from meeting the ideal KKM criteria of 75%. In line with the results of the interview, as an effort to overcome and improve the quality of human resources through education during the COVID-19 pandemic, a learning device is needed that can be used to improve students' critical thinking skills during the COVID-19 pandemic. The learning device is a flipped classroom learning device. The flipped classroom learning device is thought to be used to improve students' critical thinking skills when integrated with STEM (Science, Technology, Engineering, and Mathematics).

The integration of STEM in flipped classroom learning can provide broad opportunities for students to improve their critical thinking skills. This is because the flipped classroom learning uses learning resources in the form of online-based learning media which not only contains aspects of science but other aspects, so it is very suitable if integrated with STEM. This is in accordance with the objectives in the form of STEM which states that the formation of STEM aims to prepare students to face educational challenges in the 21st century which requires every individual to have the ability and skills to solve problems that cannot be separated from the use of technology and innovation (Anggraini & Huzaifah, 2017). The existence of STEM integration in learning can provide more varied and innovative learning because it can learn various academic concepts related to the real world. with STEM students can gain more complete knowledge, are more skilled in dealing with real-life problems and can develop students' critical thinking skills (Rohmah et al., 2019). To overcome this problem, a research is needed to develop an online-based learning tool that can be used as a solution to face the challenges of 21st century education, one of which is critical thinking, especially during the COVID-19 pandemic.

RESEARCH METHOD

This study was designed using the Research and Development design which refers to the development model of Sugiyono (2016) with 10 stages of research. The research was conducted in the odd semester of the 2021/2022 academic year at SMA N 1 Pagelaran, with research subjects a number of studies, namely class X MIPA 1. The data collection in this study used questionnaires, tests, and interviews. The data from the validity questionnaires by experts and the responses of teachers and students were analyzed descriptively by percentages with the criteria in Table 1, on the contrary, the interview data were analyzed descriptively qualitatively and the test results for evaluation tools were analyzed based on the feasibility analysis of the items.

Table 1 Eligibility criteria and responses to learning tools

Interval	Eligibility Criteria	Response Criteria
81.25 % < score ≤ 100 %	Very feasible	Very good
62.50 % < score ≤ 81.25 %	Feasible	Good
43.75 % < score ≤ 62.50%	Feasible enough	Good enough
25 % < score ≤ 43.75 %	Not feasible	Not good

Learning tools are said to be feasible to use if they get an average expert validation result of > 62.50% with a feasible category according to the assessment instrument used. Learning devices are said to be good if they get responses from teachers and students of > 62.50% with good criteria according to the assessment instrument used.

RESULTS AND DISCUSSION

Characteristics of Learning Devices

The learning tools developed were based on the results of the needs analysis in schools, especially in SMA N 1 Pagelaran. The syllabus developed in this study was adapted to the flipped classroom and STEM learning models. The syllabus developed in this study contains several aspects such as KI, KD, subject matter, learning activities, assessment, time allocation, and learning resources. The syllabus developed refers to the flipped classroom learning model which is integrated with STEM to improve students' critical thinking skills during the COVID-19 pandemic. This syllabus has characteristics that distinguish it from the syllabus published by the Ministry of Education and Culture, namely in its learning activities which consist of 2 learning activities, namely asynchronous learning (independent) and synchronous learning. The two learning activities also contain aspects of 5M. For the observing aspect, we can find online video observation activities carried out by students during asynchronous learning. For the questioning aspect, we can find the activity of making a list of questions after students observe the learning video. At home, we can meet the data collection aspect when students have discussions with group friends to collect data or information in order to answer the tasks listed in the LKS which are not only related to science but also related to other aspects such as technology, engineering, and mathematics. Associating aspects can be found in guided discussion activities guided by the teacher so that students get the right concept and there are no misconceptions in learning. And for communicating activities, we can meet when students make presentations related to the results of discussions carried out in groups. The development of this syllabus is focused on learning during the pandemic, where all learning activities are carried out online. This is in line with the opinion of Sudrajat (2008) that one of the principles in curriculum development (syllabus) is flexibility so that the resulting syllabus has a flexible or flexible nature in its implementation, thus allowing for adjustments based on time, place, situation, and time. developing conditions, as well as student abilities.

The lesson plan developed in this study uses a syntax with a flipped classroom model that is integrated with STEM. The division of time in this RPP is different from the general RPP. The division of time in this lesson plan has been adjusted to the learning model used, namely the flipped classroom model. Learning with the flipped classroom model is divided into two learning activities, namely asynchronous learning and synchronous learning. The initial activity started with asynchronous learning independently using the Google Classroom application. Shaharanee et al. (2016) stated that Google Classroom is an effective active learning tool for online learning. Then proceed with virtual synchronous learning using the Zoom Cloud Meeting application and WhatsApp Group, and end with asynchronous collaboratively using the Google Classroom application. The zoom application is a very helpful tool for communicating between educators and students, so it really supports virtual learning during the pandemic (Azmi et al., 2021). Another advantage of the zoom application is the breakout room feature that can help teachers coordinate student discussion activities in groups. This is in accordance with the learning steps of the flipped peer instruction type where students are given questions to determine the division of groups between students who are right and wrong. Meanwhile Gon & Rawekar (2017) also stated that the use of WhatsApp greatly helps the availability and ease of communication in online learning activities. The time allocation for asynchronous learning (independent) activities ranges from 12 hours, while the time allocation for synchronous learning activities is 30 minutes which includes several activities, namely, introduction, core and closing. Meanwhile, for collaborative asynchronous learning activities the time allocation is around 2x24 hours, this is intended so that students are more optimal in doing the tasks given. The lesson plans developed not only use the flipped classroom model but are integrated with STEM. The STEM aspect of this lesson plan is contained in learning activities and in the tasks given. For example, the science aspect can be found in the activities of watching learning videos, making summaries, making lists of questions, analyzing articles, and discussion questions. Technological aspects can be found in activities when students access video links, look for data or information, and discuss questions. The engineering aspect can be found in the activities of making posters or discussion questions, while the mathematics aspects can be found in the activities of designing poster sizes

and the costs used, making conclusions, and discussing questions. The integration of STEM in the lesson plans is intended so that students not only gain knowledge about science but also have other knowledge and skills in fields such as technology, engineering, and mathematics. In addition, the integration of STEM in learning can be used to develop student skills, especially critical thinking skills.

The student worksheets developed in this study used a flipped classroom model that was integrated with STEM to improve students' critical thinking skills. The learning activities listed on the student worksheets have been designed for the implementation of asynchronous learning and synchronous learning activities. This worksheet contains instructions for use, video links to learning materials that can be accessed by students for independent asynchronous learning activities. In addition, there is a column for summarizing and a list of questions after listening to the video. This worksheet is equipped with a video link that is connected to Youtube for students to observe when independently asynchronously. A column is also provided to summarize the contents of the video and a column to make a list of questions that have not been mastered, which can then be asked to the teacher. Video-based learning is an alternative so that students are able to understand the learning material well in order to achieve maximum and more effective results. This is in accordance with the opinion Falahudin (2014) which states about the benefits of using video-based learning media, namely: 1. the material presented can be equated, 2. the learning process is clearer, more complete and attracts students' interest, 3. the learning process becomes more interactive, 4. time and energy efficiency, 5. can improve the quality of student learning outcomes, 6. media allows learning activities to be carried out anywhere and anytime, 7. media can foster positive attitudes for students towards the material and learning process, 8 change students in a more positive and productive direction, 9. media makes abstract material more concrete, 10. media can also overcome the constraints of space and time limitations, 11. media can help overcome the limitations of the human senses. The worksheets developed were arranged for 3 meetings, each of which consisted of watching videos, summarizing the contents of the video, making a list of questions, discussion questions containing STEM aspects, and analyzing scientific articles related to the material being taught which was intended to train skills. students' critical thinking. The questions presented in the LKS are in the form of interpretation and analysis of problems related to biodiversity that are often encountered in everyday life, which are intended to train students in developing their critical thinking skills. This is in line with the opinion of Ardianto & Rubini (2016) which states that when students are interacting with the environment through phenomena or problems that are happening, students are indirectly involved in a process, namely the development of thinking skills. In addition to questions in the LKS, it also contains activities to analyze scientific articles which are intended so that students can have the ability to interpret and analyze data or information, so that students have critical thinking in making decisions or finding solutions to problems that exist in everyday life.

The evaluation tool developed contains 5 learning indicators related to biodiversity material. The questions developed are in the form of multiple choice with 5 kinds of answer choices. Each item developed contains one aspect of STEM and critical thinking indicators (interpretation and analysis). The questions developed not only present problems related to science but also other problems related to technology, engineering, and mathematics.

Eligibility of Learning Devices

The feasibility of the developed learning device can be determined based on the results of the lecturer's validation. The validation of the syllabus and lesson plans is carried out by expert lecturers in the field of learning, validation of the worksheets by material and media expert lecturers, and evaluation tools validation is carried out by evaluation experts. The complete validation results can be seen in the following tables.

Table 2 Product Validation Results by Experts

Components	Data Source	Percentage	Criteria
Syllabus	Learning Experts	93,75%	Very Feasible
RPP	Learning Experts	86,45%	Very Feasible
LKS	Material Experts	82,50%	Very Feasible
	Media Experts	93,33%	Very Feasible
Evaluation Tool	Evaluation Experts	94,33%	Very Feasible

The feasibility of the developed learning device can be determined based on the results of the lecturer's validation. The results of the validation of the syllabus get a feasibility percentage of 93.75% with a very feasible category. The results of the validation indicate that the syllabus developed is in accordance with the syllabus development instructions so that it is feasible to be used in STEM-based integrated flipped classroom-based learning to improve students' critical thinking skills. On average, each item of the statement received a response of strongly agree and agree, but it needs a little improvement to highlight the flipped classroom and STEM components in learning activities. The results of the validation of the learning implementation plan (RPP) get a feasibility percentage of 86.45% with a very feasible category. The results of the validation indicate that the lesson plans developed are in accordance with the guidelines for developing lesson plans and are feasible to be applied in online learning. On average, the results of the RPP assessment received a response of strongly agree, and agree, but there were 2 statements that received quite agreeable responses, namely on the learning step items. this indicates the need for improvement in the RPP. The improvement is by highlighting the activities carried out by students in the learning step. The results of the validation of the student worksheets (LKS) obtained material eligibility criteria of 82.50% and media eligibility criteria of 93.33%. This proves that the LKS developed is in accordance with the rules for developing LKS and is suitable to be used as a companion in learning activities with several improvements such as adding a bibliography, adding a library to each picture, improving the language used by not using conjunctions at the beginning of sentences, clarifying the characteristics of the LKS. on the cover page, clarifying instructions related to STEM elements, improving the writing structure on worksheets, fixing the size of plumeria alba images and other images, improving margins and layouts. The results of the validation of the evaluation tool obtained a feasibility percentage of 94.33% with a very feasible category. The assessment on this evaluation tool includes 3 aspects, namely material, construction, and language. From these results, it is stated that the evaluation tool developed has included STEM aspects and critical thinking indicators (interpretation and analysis) so that it is declared eligible as a good and appropriate evaluation tool to be applied in flipped classroom-based learning to measure students' critical thinking skills. This is supported by the opinion of Arikunto (2019) which states that an evaluation tool can be said to be good if the evaluation tool can evaluate something with results such as the conditions being evaluated. In addition, Sartika (2019) also stated that the evaluation tool is a tool used to assess and evaluate the extent to which the learning process can be conveyed to students. Based on the validation results that have been carried out, it proves that the learning tools developed in the form of syllabus, lesson plans, worksheets, and evaluation tools are in accordance with the development rules and are suitable for use in STEM integrated flipped classroom learning on biodiversity material to improve students' critical thinking skills.

Small-Scale Trial

The learning tools developed will be tested on teachers and students at SMA N 1 Pagelaran. The test of this evaluation tool aims to determine whether the evaluation tool developed meets the eligibility criteria in accordance with the item analysis (validity, level of difficulty, discriminating power, and reliability) which will later be selected for use in large-scale tests to measure students' critical thinking skills. The following are the results of student and teacher responses to the developed learning tools (syllabus, lesson plans, worksheets, and evaluation tools) according to the following tables.

Table 3 Teacher's Response to Learning Tools

Components	Data Source	Percentage	Criteria
Syllabus	Teacher	95,31%	Very good
RPP	Teacher	94,79%	Very good
LKS	Teacher	95,00%	Very good

The results of the teacher's response to the developed syllabus obtained a percentage of 93.00%, then the RPP was 95.00% and the LKS was 93.00% with each criterion being very good. The teacher also gave a few comments that the learning tools developed were good and could be applied in learning on biodiversity material during the new habit period due to the COVID-19 pandemic. The teacher also gives suggestions on

the developed lesson plans so that the indicators between KD 3.2 and 4.2 are separated so that they are clearer. Based on the results of interviews with biology teachers at SMA N 1 Pagelaran, it can be seen that the learning tools developed have met the needs of KD 3.2 and 4.2. The learning activities designed are in accordance with the flipped classroom model which is integrated with STEM to improve students' critical thinking skills. The advantage of this learning is that learning time is more flexible, when in class students already have knowledge related to the material because they have studied at home first so that time for discussion is really used properly for understanding concepts, and in one lesson students can gain knowledge or skills in the field. other fields such as technology, engineering, and mathematics, not only about science.

Table 4 Student Responses to the LKS developed

No	Student's name	Question												Score	Percentage	Criteria
		1	2	3	4	5	6	7	8	9	10	11	12			
1	A	4	3	3	4	4	4	3	4	3	4	3	4	43	89,58%	Sangat Baik
2	B	4	3	4	4	3	4	4	4	3	4	4	3	44	91,16%	Sangat Baik
3	C	4	4	3	4	4	3	4	4	3	4	4	3	44	91,16%	Sangat Baik
4	D	4	3	3	4	4	4	4	4	3	3	4	3	43	89,58%	Sangat Baik
5	E	3	4	3	4	3	4	3	4	3	4	3	4	42	87,50%	Sangat Baik
6	F	4	3	4	3	3	3	4	4	3	4	4	4	43	89,58%	Sangat Baik
7	G	4	3	3	4	4	4	4	3	4	4	3	4	44	91,16%	Sangat Baik
8	H	3	4	3	3	4	3	3	4	3	3	4	3	40	83,33%	Sangat Baik
9	I	4	3	3	4	4	4	4	3	3	4	4	4	44	91,16%	Sangat Baik

The results of the LKS readability analysis on the small-scale test show the percentage of student A is 89.58%, the percentage of student B is 91.16%, the percentage of student C is 91.16%, the percentage of student D is 89.58%, the percentage of student E is 87 .50%, the percentage of student F is 89.58%, the percentage of student G is 91.16%, the percentage of student H is 83.33%, the percentage of student I is 91.16%, and the percentage of student J is 89.58% with each category is very good. These results indicate that the developed worksheets can be applied in classroom learning, especially on biodiversity material. With this development, it is hoped that the LKS will be able to help students understand the material and practice in order to develop their thinking skills. This is supported by the opinion of Prastowo (2015) which states that one of the functions of LKS is as teaching materials that can make it easier for students to understand the material, as teaching materials that are concise and rich in questions that students use to practice. In addition to these data, there is also qualitative data derived from student suggestions or comments. On average, students gave positive comments on the developed LKS. One of the advantages of the LKS developed is the availability of video links related to the material being taught. With the video link, it can make students interested in learning, making it easier for students to understand the learning material. In addition, with learning videos, students can easily review which parts they have not understood. According to Saputra & Mujib (2018) there is a positive influence on students who are treated with flipped classroom learning using learning videos. This is because students can freely study material through videos, thus making students more enthusiastic and interested in learning during the new habits of the COVID-19 pandemic. This is due to the flexible nature of the video, which can be paused, rewinded, and can be replayed (repeat) until students really understand (Apriyanti et al., 2016). In order for the worksheets to be developed better, students also provide some suggestions for improvement, such as improving the writing order, and increasing the size of the image so that it is clear and not blurry. The results of the LKS readability trial have not reached a 100% percentage this is due to differences in students' ability to understand information. There are some students who can understand information quickly and there are students who take a long time. This is because many students do not understand the meaning of the words used.

The evaluation tool developed was tested on 30 students of class XI Mathematics and Natural Sciences 1. The evaluation tools tested were 50 questions. The test results of the evaluation tool were then analyzed using the Test Analysis Program software. The evaluation tool developed refers to 5 learning indicators. from the results of the analysis, 30 items were selected that represent 5 learning indicators containing STEM aspects and critical thinking indicators (interpretation and analysis). Item analysis has a function to assist in

identifying bad items, and assist in obtaining information that can be used to improve bad questions, so that from the analysis one can obtain a good item that can be used to measure development or progress. progress of student learning outcomes (Arikunto, 2019). In analyzing the items, there are several aspects that need to be considered, namely validity, reliability, level of difficulty, discriminating power, and the pattern of distribution of answers or a distracting function for each answer choice.

Proof of validity aims to examine the validity of measuring instruments or questions or to examine the stability or determination of the results of a test. An evaluation tool can be said to have high validity if the tool is able to measure or provide measurement results that are in accordance with the purpose of the measurement. This is supported by the opinion of Hughes in Nurjanah & Marlianingsih (2015) which states that a test can be said to be valid if the test can accurately measure what should be measured. Analysis of the level of difficulty of the questions serves to group the questions into easy, medium, and difficult categories. The magnitude of the index of difficulty obtained indicates that the questions developed are in the easy category. While the analysis of discriminating power serves to examine whether the questions developed are able to distinguish students into categories who have high or low abilities (Nurjanah & Marlianingsih, 2015). The higher the discriminatory power index, the better the question can distinguish the ability between smart students and less intelligent students. Therefore, items that are suitable for use must have a moderate level of difficulty and a high index of discriminating power. The next aspect in item analysis is the pattern of distribution of answers or a distracting function. Good items, distractors will be chosen evenly by students who answer wrongly. Conversely, items that are not good, the distractor will be chosen unequally by students. Distractor or distractor is the wrong answer choice. From the pattern of answer questions, it can be determined whether the distractor is functioning properly or not. The distractors that were not selected at all by the students indicated that the distractors were ugly, too conspicuous and misleading. A distractor can be said to function as a distractor if it can provide a great attraction for students who do not understand the concept of choosing the wrong answer. This is supported by the opinion of Sudijono (2015) which reveals that each distractor can be said to function if the distractor is selected at least 5% of the total test takers.

Based on the test results of the evaluation tool, it can be seen that there are 30 questions that can be used in the trial use and 8 questions that are problematic. The 30 questions are questions number 1,2,3,4,5,6,9,15,16,17,18,19,23,24,25,26,27,28,31,33,34,37, 39,41,42,48. In addition, there are also 8 problematic items, namely questions number 8, 10, 20, 22, 29, 32, 43, and 46. In questions number 8 and 43 the correct answer choices were answered by 4 out of 10 students, the question was problematic because students are more inclined to the third and fourth answer choices. In question number 22 the correct answer was answered by 2 out of 10 students, the question was problematic because only 2 students were able to answer correctly. Both students came from high group students. This causes the discriminatory power of the questions to be low, namely 0.00. In question number 10 the correct answer was answered by 6 out of 10 students, question number 20, the correct answer was answered by 9 out of 10 students, question number 29 correct answer was answered by 8 out of 10 students, question number 32 correct answer was answered by 8 from 10 students, and question number 46 with the correct answer was answered by 6 out of 10 students. The five questions are problematic because they cannot distinguish the abilities of students who are smart and those who are less intelligent. It can also be seen from the differentiating power of the five questions in a row, namely 0.00, 0.00, 0.00, 0.00, and 0.00 with a bad category. The discriminatory power of the questions with a small value indicates that the questions do not function to distinguish students who have low abilities and students who have high abilities. In addition, calculations were carried out using the Spearman-Brown formula, obtaining a reliability value of 0.949. Because the calculated R value (0.949) > R table (0.248), it shows that the evaluation tool developed is very reliable, so it can be used to measure students' critical thinking skills. These problematic questions were not included in the selection of evaluation tools. Based on the results of the analysis of the questions, 30 items were selected that were suitable to be used for the usage test.

The researcher also conducted interviews with several students who were involved as subjects in the evaluation tool trial. Based on the results of the interviews, students showed enthusiasm for the evaluation

tool developed. This is because the evaluation tool developed does not only contain scientific knowledge but includes other knowledge such as technology, engineering, and mathematics. So that students can get a lot of information from learning materials that can be applied in everyday life. One example is the use of biodiversity as an alternative product. For this reason, teachers are expected to be able to provide learning that connects problems with theory in the classroom. Students also think that the problems presented in the questions are not as simple as those taught by the teacher in class, so to be able to overcome these problems requires critical thinking. Therefore, teachers are expected to be able to apply more complex learning that supports students to be able to develop their critical thinking skills so that they can overcome the problems in the questions. By working on evaluation tools developed students' critical thinking skills will develop so that students become trained in solving problems that exist in the environment in everyday life, using STEM knowledge (science, technology, engineering, and mathemtaics).

Large-Scale Trial

Learning tools that have been revised will then be used for trial use. This trial was conducted at SMA Negeri 1 Pagelaran. This trial is carried out by applying learning tools that have been validated and revised in teaching and learning activities. In this trial, the use of worksheets and evaluation tools were tested. The trial of this tool aims to determine whether there is an effect of applying the learning tools that have been developed on students' critical thinking skills after carrying out learning. In addition, from the trial use of this product, it can be seen the obstacles that arise during the use of learning tools developed for further improvement. The results of the trial using the evaluation tool will be analyzed using a software, namely SPSS. From this analysis, it can be seen whether there is an influence on students' thinking skills after carrying out learning with the STEM integrated flipped classroom model. The following is the result of the analysis of students' thinking skills using SPSS software.

Table 5 Test of Normality

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	Df	Sig.
Unstandardized Residual	0,084	30	.200*	0,960	30	0,317

***. This is a lower bound of the true significance.**

a. Lilliefors Significance Correction

Table 6 Test of Homogenity

Test of Homogeneity of Variances					
		Levene Statistic	df1	df2	Sig.
Result	Based on Mean	18,294	1	58	0,000
	Based on Median	18,358	1	58	0,000
	Based on Median and with adjusted df	18,358	1	44,419	0,000
	Based on trimmed mean	18,299	1	58	0,000

Table 7 Paired Sample Statistics

Paired Samples Statistics					
		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	PRETEST	5,3000	30	1,42151	0,25953
	POSTEST	7,6200	30	0,66457	0,12133

Table 8 Paired Sample Correlations

Paired Samples Correlations				
		N	Correlation	Sig.
Pair 1	PRETEST & POSTEST	30	-0,390	0,033

Table 9 Paired Sample Test

Paired Samples Test									
		Paired Differences					T	Df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	PRETEST – POSTEST	-2,32000	1,78855	0,32654	-2,98785	-1,65215	-7,105	29	0,000

The results of the normality test in table 5 show that the significance (p) of the Kolmogrov-Smirnov test is 0.2. Because the p value > 0.05, the results of the Kolomogrov-Smirnov normality test showed that the pre-test and post-test values obtained were normally distributed. The significance value (p) in the Shapiro-Wilk test is 0.317. Because the p value > 0.05, it indicates that the pre-test and post-test data obtained are normally distributed, so the data can be used as a condition for the t-test.

The results of the homogeneity test in table 6 show that the pre-test significant value obtained is 0.00 and the post-test significant value obtained is 0.000. Because the significance value of 0.000 <0.05 indicates that each group of data comes from a population with different variances (not homogeneous). Homogeneity of the data obtained is not a problem in the paired sample t-Test, this is because the homogeneity of variance is not an absolute requirement in the use of the paired sample t-Test.

The first output is the paired sample statistics test. The test results indicate that the average value of student learning outcomes before and after applying the developed learning tools. Before using the learning tools, the average score (pre-test) of students was 5.3000, while after applying the learning tools the average score (post-test) of students was 7.6200. Std value. Deviation in the pre-test is 1.42151 and at the post-test is 0.66457. Std value. The mean error for the pre-test is 0.25953 and the post-test is 0.12133. Because the average value of learning outcomes in the pre-test is 5.3000 < post-test 7.6200, descriptively it shows that there is a difference in the average learning outcomes between the pre-test and post-test.

The second output is paired sample correlations. The test results show that the correlation coefficient obtained is -0.390, with a significance value of 0.033. Because the significance value is 0.033 < (0.05), it shows that there is a relationship between the pre-test and post-test variables.

The third output is the paired sample test, the results show that the t value obtained is 7.105, the df value obtained is 29 and the Sig (2-tailed) value obtained is 0.00. Because the value of Sig 0.00 < (0.05) which indicates an average difference between the pre-test and post-test scores. From these results, it can be concluded that the critical thinking skills of students at SMA N 1 Pagelaran have increased after implementing learning using flipped classroom learning devices that are integrated with STEM on

biodiversity material to improve students' critical thinking skills. This is also supported by the opinion of Maolidah et al. (2017) which states that learning with the flipped classroom model is not just learning to use learning videos but, more emphasizing the use of class time so that learning is of higher quality and can be used to hone skills in thinking and communicating. In addition, empirical evidence that supports the positive effect of flipped classroom learning on students' critical thinking skills is shown through several studies, the first of which is Alfina et al. (2021) in this study it can be seen that the flipped classroom learning model is effective in improving the mathematical critical thinking skills of the students of SMP Negeri 1 Angkola.

The results of this study are in line with the research conducted by Maolidah et al. (2017) which shows that the application of the flipped classroom learning model is effectively used to improve students' critical thinking skills. The implication in the application of the flipped classroom learning model in the learning process is that there is a process of interaction between students and teachers and their learning environment, so that learning can create an active learning atmosphere for the development of thinking skills. Learning using the flipped classroom model can improve student learning outcomes. In addition, the flipped classroom learning model can also be applied to increase student activity in deepening the material, and increase student interaction in discussions in order to achieve learning outcomes in the realm of higher-order thinking.

Learning with the flipped classroom model is effectively used to face the challenges of 21st century education if it is integrated with STEM, this is because STEM is a discipline that is related to one another. Science requires mathematics as a data processing tool, while technology is an application of science itself. Science learning also requires an engineering design process, namely the knowledge to operate or design a procedure for problem solving (Afriana et al., 2016).

The application of flipped classroom learning that is integrated with STEM can improve students' understanding of concepts related to the material. Improved understanding of this concept can be seen from the activeness of students in the classroom in the learning process. This is in accordance with Sartika's research (2019) which shows that STEM integration can provide more meaningful learning for students, because the learning links concepts, principles, technology, techniques and mathematics that are integrated with each other so that in the learning process students are able to increase mastery of concepts. STEM integration in learning can also improve higher order thinking skills because this model is able to facilitate students to solve problems, think critically, think creatively, and think scientifically (Baharin et al., 2018).

CONCLUSION

The conclusions of this study are: (1) the characteristics of the learning tools developed in this study were designed with the flipped classroom model as developed by Steele which was integrated with stem to improve students' critical thinking skills consisting of asynchronous learning and synchronous learning activities, (2) devices learning that has been developed is suitable for use in learning. This is based on the results of expert validation on all components of the learning device with very feasible criteria, and (3) the results of the large-scale trial show that the students' scores on the pre-test < post-test. from these results it can be concluded that the critical thinking skills of students at SMA N1 Pagelaran have increased after implementing learning using flipped classroom learning tools that are integrated with STEM on biodiversity material.

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