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The Effect of STEM (Science, Technology, Engineering, and Mathematics) based Textbooks in Biotechnology Learning Material on The Critical Thinking Skills and Learning Results of Senior High School Students in The Industrial Agriculture Area

Kamilatul Khoiroh, Bea Hana Siswati*, Kamalia Fikri
Biology Education Department, Faculty of Teacher Training and Education, Universitasity of Jember, Kalimantan Street Number 37, SUmbersari, Jember 68121, Jawa Timur, Indonesia
*Corresponding Author. E-mail address: beahana.fkip@unej.ac.id

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ABSTRACT

The study entitled the effect of STEM (Science, Technology, Engineering, and Mathematics) based textbooks in biotechnology learning material on the critical thinking skills and learning results of senior high school students in the industrial agriculture area. The purpose of this study was to determine the effect of STEM-based textbooks on the subject of biotechnology on critical thinking skills and student learning outcomes in industrial agriculture areas. This type of research is quasi-experimental research (quasi experiment). The sampling technique was carried out through the normality test and ANOVA homogeneity test using the end of semester exam scores for biology subject then the determination of the sample was carried out randomly (random sampling). The research samples were class XII MIPA 2 as the experimental class and XII MIPA 4 as the control class. The place of this research is at SMAN 3 Jember. Data analysis used the covariance analysis test (Anacova) and Independent Sample T-Test for data that met the parametric test requirements, namely normal and homogeneous. The significance value obtained was <0.05 so it can be concluded that there is an influence of STEM (Science, Technology, Engineering, and Mathematics) based textbooks on the subject of biotechnology on critical thinking skills and learning outcomes.

1. INTRODUCTION

The 21st century is characterized by the implementation of learning that is balanced due to the rapid development of science and technological advances so that information can be accessed easily (Angin, 2020). The ease of accessing information needs to be balanced with critical thinking so that the information obtained can be filtered properly (Hasibuan and Prastowo, 2019). Thus, the skills to deal with learning in the 21st century era must be mastered by students, one of which is critical thinking skills (Rusyati *et al.*, 2019). Critical thinking skills according to Mustafa and Dwiyogo (2020) are important for learners to master because the ability to conclude logically requires a directed mindset so that the assessment of certain information or situations can be considered carefully and based on the assessment of evidence in the form of knowledge, thoughts, and experiences (Girsang *et al.*, 2022). Meanwhile, critical thinking skills in Indonesia as shown by data in 2015 with a score of 397 are still ranked 62nd with a total of 72 countries participating, while data in 2018 Indonesia is still ranked 71 out of 79 participating countries based on the Program for International Student Assessment (PISA). So it can be concluded that the critical thinking skills of students in Indonesia are still relatively low (Agnafia, 2019; Sa'adah *et al.*, 2020).

In addition to critical thinking, student learning outcomes are an important indicator in learning that describes students' mastery of certain knowledge or skills (Sulfemi and Mayasari, 2019). In this case, if student learning outcomes meet the minimum assessment criteria, it can be indicated

that students' critical thinking skills are also good (Dakhi, 2020). The problem found is that student learning outcomes are still classified as a low category in the results of research by Zulpadly (2016) that out of 644 students, 574 students' biology grades, especially in biotechnology material, are declared incomplete or have not met the KKM (minimum completeness criteria). Other data that support this statement are research by Inayatin (2020) that the average value of learning outcomes in biotechnology material is still not complete, with a percentage of learning completeness of 56.2% of the desired target of 85%. Factors that cause low learning outcomes are caused by external factors and internal factors. External factors, for example, school facilities such as laboratories and the availability of textbooks, while internal factors such as students' interest, motivation, and talent. External factors get a percentage of 44% followed by internal factors with a percentage of 43% with details of the factors causing the availability of textbooks of 45% which is ranked second highest after internal factors, namely talent at 50% (Nasution *et al.,* 2022; Rahmadani *et al.,* 2017).

External factors, namely textbooks, play an important role because textbooks contain all teaching materials that must be mastered by students during the learning process (Kosasih, 2020). According to Yuanita and Kurnia (2019) the use of textbooks during learning can support students to learn independently and with this opportunity students will be free to explore the knowledge being studied. In addition, the use of textbooks in the classroom can concretize something abstract so that it can facilitate students' difficulties in understanding the material. One of the abstract biology materials is biotechnology material. This material is actually an interesting topic because the application of this material is very related to everyday life, it should be easier to convey to students. But in fact, this material is difficult to convey because the explanation of molecular biotechnology and textbooks supporting this material in Indonesian are still limited (Purwaningsih, 2019). Biotechnology includes material that explains how to apply living organisms to services and manage the environment, which is closely related to activities in industrial agricultural areas. Learning about this material in industrial agricultural areas should be packaged and delivered to be more meaningful (Anantyarta and Sholihah, 2020). One of the industrial agricultural areas is Jember Regency (Reykasari *et al.,* 2021). Industrial agricultural areas are characterized by an abundance of natural resources with good soil fertility, making them suitable for the agricultural or agro-industrial sector because they have the potential to produce various products and can support a variety of consumption needs in the form of food or as raw materials for other industries (Husniah *et al.,* 2019). Thus, these environmental conditions have the potential to be associated with learning activities for surrounding schools so that the learning carried out in the classroom is in line with the conditions around industrial agricultural areas. This is different from the current situation where many schools have not yet associated and accommodated learning that features activities or problems in industrial agricultural areas (Pasuari, 2022). Based on this, an alternative that can be applied is to use STEM-based textbooks, especially on the subject of biotechnology in the learning process in industrial agricultural areas. The STEM-based textbook is a book that is integrated with four aspects of scientific disciplines (science, technology, engineering, and mathematics) so that students can gain an understanding that the knowledge gained is very useful and can explain phenomena that occur in the real world (Izzah *et al.,* 2021).

2. MATERIALS AND METHODS

The type of research included quasi-experiment research at SMAN 3 Jember in the even semester of the 2022/2023 school year through random sampling techniques through the equality test. The research samples selected were XII MIPA 4 class as the control class and XII MIPA 2 as the experimental class with the number of students in each class as many as 31. The research design used was Pre Test Post Test Control Group Design which is as follows.

Table 1. Research Design

Class	*Pre Test*	Learning	*Post Test*

E	O1	X1	O2
K	O3	X2	O4

(Source: Rahma, 2021)
Information:
E : Experimental class
K : Control class
O1 : Pre test results of the experimental class
O2 : Post test results of the experimental class
O3 : Pre test results of the control class
O4 : Post test results of control class
X1 : Learning using STEM-based textbooks
X2 : Learning using ordinary textbooks

Data collection techniques in this study include interviews, observation, tests, and documentation. Interviews were conducted to obtain initial data regarding conditions, models, and textbooks used during learning. Observations are used to retrieve data on affective and psychomotor learning outcomes. The indicators of affective learning outcomes that are measured include focus on learning, active participation, respect, and responsibility. Indicators of psychomotor learning outcomes that are measured include preparing practicum tools and materials, carrying out practicum according to procedures, criticizing the results of the observation data obtained, and concluding the observations. The instrument used to measure cognitive learning outcomes or the domain of students' cognitive knowledge and critical thinking skills uses tests, namely through pre-test and post-test. The critical thinking indicators that are measured include focusing questions, analyzing arguments, identifying assumptions, understanding situations, explaining the meaning of key terms, and determine the results of the conclusion. Other supporting data is in the form of photo documentation during learning activities during this research.

The analysis technique used in this study for cognitive learning was analyzed using a parametric test, namely the *Anacova Test* after the prerequisite test was carried out, namely the data must be normal and homogeneous. The *Anacova Test* used to analyze critical thinking skills data and cognitive learning outcomes while affective and psychomotor learning outcomes data used the *Independent Sample T-Test* analysis.

3. RESULTS AND DISCUSSION

3.1. Data Results of Critical Thinking Skills

Data on students' critical thinking skills obtained are shown in **Table 2.** The summary of the data is as follows.

Table 2. Summary of Critical Thinking Data

Component	Class			
	Experiment		Control	
	Pre Test	Post Test	Pre Test	Post Test
The Highest Score	66,6	100	62,5	100
The Lowest Score	37,5	79	33,3	79

Based on **Table 2.** it is obtained that the average value of critical thinking in the experimental class is greater than that of the control class, but further data analysis is needed to determine the difference in significance between the two classes using Anakova.

Based on the results of the *Anacova Test*, critical thinking data obtained Sig. (2-tailed) namely 0.000 <0.05, so that it can be interpreted that H_0 is rejected and H_1 is accepted, namely there is a significant difference in the use of STEM-based textbooks on students' critical thinking skills between the experimental class and the control class. Can be seen in **Table 3.** below:

Table 3. *Anacova* Hypothesis Test for Critical Thinking Skills

Class	N	Average				F	Sig.
		Pre Test	Std. Deviation	Post Test	Std. Deviation		
Experiment Class	31	51,02	8,11	91,50	5,75	16,9	0,00
Control Class	31	47,40	7,25	87,45	6,20		

Then, to find out the difference in the value of critical thinking on each indicator for the experimental class and the control class is shown in **Table 4.** below:

Table 4. Frequency Distribution of Critical Thinking Skills

Num.	Critical Thinking Indicator	Experiment Class			Control Class		
		Average *PreTest*	Average *PostTest*	Average Difference	Average *PreTest*	Average *PostTest*	Average Difference
1	Focusing questions	2,74	4,00	1,26	2,77	4,00	1,23
2	Analyze arguments	1,68	3,00	1,32	1,29	2,61	1,32
3	Identify assumptions	1,61	3,35	1,74	1,39	3,10	1,71
4	Understanding the situation in thinking	1,77	3,61	1,84	1,52	3,32	1,80
5	Explain the meaning of key terms	2,13	4,00	1,87	2,13	4,00	1,87
6	Determine the results of the conclusion	2,32	4,00	1,68	2,32	4,00	1,68
	Total			9,71			9,61

Based on **Table 4.** It is well known that each critical thought indicator is increasing in both experimental and control classes. As for the same indicators that increase in experiment and control classes, that are indicators that analyze arguments, explain the meaning of key terms and determine the outcome of conclusions. While the indicator of improvement is higher in experimental classes than the control class is on indicators of focusing questions, identifying assumptions, and understanding the situation in thinking.

3.1.1. The Effect of STEM-Based Textbooks on Biotechnology Subjects on Critical Thinking Skills

This study aims to find out how the influence of the use of STEM-based textbooks, especially on Biotechnology material, is compared to the use of textbooks commonly used by teachers at SMAN 3 Jember on students' critical thinking skills. Critical thinking is self-regulation in making a decision that involves an intellectual process through interpretation, analysis, evaluation, and considering the presentation of information using evidence as a basis for making decisions (Syafitri *et al.*, 2021). According to Herunata *et al.* (2020) critical thinking skills can be trained and developed through various fields of study such as Biotechnology. Students' critical thinking flow can also be trained by solving test questions or contextual problems related to everyday life. The 6 indicators of critical thinking put forward by Ennis are focusing questions, analyzing arguments, identifying assumptions, understanding situations in thinking, explaining the meaning of key terms, determining the results of conclusions, which are relevant to the material and subject matter contained in STEM-based textbooks .

In this study, it was found that STEM-based textbooks had a significant effect on students' critical thinking skills (**Table** 4.2). This is in accordance with the results of research by Nugraha

and Syafi'ah (2020) which state that STEM-based textbooks can improve students' critical thinking skills because students' interest in learning science is much higher than using ordinary textbooks. Aspects which include *Science, Technology, Engineering and Mathematics* contained in textbooks have an impact on increasing students' skills in critical thinking. In addition, textbooks that contain contextual problems become reinforcement for students to understand the material being studied with problems that exist in everyday life (Oktaviani *et al.*, 2022).

Besides that, according to Setyowibowo and Prasetyo (2017) Jember Regency, which is an industrial agricultural area, has a community that develops one of the biotechnology products, namely tofu and tempeh as an alternative food in the village so that real phenomena in life are discussed directly in class. This also helps students to understand the difference between knowledge and its direct application in their environment so that students gain good mastery of concepts and improve their critical thinking skills (Puspitasari *et al.,* 2021). Other research that explains the superior product of the Jember industrial agricultural area, namely edamame, is currently still being developed through improvements starting from planting, using pesticides and fertilizers to maintain its quality (Munir and Masyhuri, 2021). With the existence of a phenomenon that is closely related to biotechnology material, it is then discussed together and students can explain the material and give examples of certain events that are around them. This can motivate students further so that students are able to connect the concepts obtained with the real world. Thus, patterns of thinking and reasoning that are trained continuously during learning can trigger students' critical thinking skills (Oktaviani *et al.*, 2022).

In addition, STEM-based textbooks that are attractively packaged make students more enthusiastic and not bored while learning. also the use of language that is easily complemented by appropriate text and image captions will increase the reader's interest in acquiring new knowledge so that their critical thinking skills will also increase (Rizkika *et al.*, 2022).

Based on **Table 4.** it is found that the first indicator of critical thinking is focusing on the question of the difference in the average experimental class being higher than that of the control class. This indicator requires students to identify the problems and elements contained in the problem so students can understand and reformulate the problem to be simpler (Apiati and Hermanto, 2020). Students' ability to focus on questions can increase because STEM-based textbooks provide certain book features, in this case, "Case Studies" which increase students' understanding of basic concepts by presenting interesting and reliable data so that they can help students with difficulty in interpreting and condensing information. Zulaiha and Kusuma, 2020). This indicator according to Sa'adah *et al.* (2020) aims to train students to focus on determining the questions contained in the questions.

The second indicator is analyzing the argument that the difference in the average values obtained by the experimental class is the same as the difference in the average values obtained by the control class. However, the average post-test score for the experimental class was higher than that for the control class. This is because in STEM-based textbooks, reading is presented about contextual problems related to everyday life, both local, national and global problems. According to Santosa *et al.* (2021) material packaged in this way can lead students to understand the concept of biotechnology effectively and facilitate students during learning to practice analyzing readings and arguing. In addition, students also find it easier to generate their own arguments and present them after going through the stages of evaluating information sources and identifying appropriate reasons to support the conclusions of these arguments (Roviati and Widodo, 2019). According to Agoestanto *et al.* (2019) analyzed arguments including critical thinking skills which involve aspects of logic to think so that in this indicator students are presented with a problem and then students are asked to give opinions on this problem. Thus, students can provide arguments and defend them from the results of the interpretation of the information or evidence obtained.

The third indicator is identifying assumptions that have a higher average value in the experimental class than the control class. Identifying assumptions is defined as the student's ability to determine which opinion is correct or which opinion is wrong by considering rational reasons

and also based on understanding the correct basic concepts (Agustina, 2019). The increase in students' abilities towards this indicator is because STEM-based textbooks are equipped with the "Did You Know?" feature. so that this feature can train students' reasoning and representation abilities. This opinion is reinforced by Nurhidayat and Asikin (2021) who state that the presentation of additional features regarding the material is accompanied by interesting illustrations, examples that are closely related to everyday life, and the use of the latest technology related to the material being studied makes it easier for students to understand the concept thoroughly so that students can distinguish the appropriate assumptions.

The fourth indicator is understanding the situation, which means students' ability to understand and maintain situations in thinking to help clarify questions and know meaning as a support for decisions taken (Affandy *et al.*, 2019). The average value obtained for this indicator is higher in the experimental class compared to the control class. This is because in STEM-based textbooks it has been reconstructed in a simple way so that it can enrich students' knowledge by inserting additional information that can strengthen the concept of the material being discussed (Rusyati *et al.*, 2019). The additional information referred to is the “Info at a Glance” feature in STEM-based textbooks that can provide students with learning opportunities to explore Biotechnology material in more detail so that the learning experience obtained is more meaningful (Davidi *et al.*, 2021). To measure students' ability on this indicator, students are given questions that are faced with a situation regarding one of the manufacture of biotechnology products, then students have to answer what will happen to the product if it is in conditions like the problem.

The fifth indicator, namely explaining the meaning of key terms, has the same average value between the experimental class and the control class, meaning that in this indicator students do not experience any difficulties. Explaining the meaning of key terms, which means students are asked to identify and understand the relationship between the statement and the concept of the problem given so that they are able to describe the description correctly (Hidayati *et al.*, 2021). The similarity in the average scores obtained is because students are used to understanding the key issues that cause a certain situation and then providing an explanation of the meaning of the terms used after re-examining in making decisions (Harianada *et al.*, 2022). In line with the opinion of Maziyah and Hidayati (2022) who stated that STEM-based textbooks are suitable for use during learning because they can stimulate students' critical thinking skills so that students are able to analyze and carry out investigations when asked to interpret certain terms into a statement.

The sixth indicator determines the results of conclusions, namely the ability of students to determine results based on a background of facts and consider them into rational final conclusions (Rohmah *et al.*, 2021). Based on the results obtained, the total average difference of the six indicators of critical thinking in the experimental class is higher than that of the control class. This shows that the use of STEM-based textbooks has an effect on students' critical thinking skills because STEM-based textbooks provide learning material facilities for students with STEM aspects that occur in real life so that they can develop students' reasoning and analytical abilities (Andini *et al.*, 2022) . Part of the STEM-based textbook that trains students is the presentation of information about the material compiled in relation to new knowledge so as to increase students' understanding of concepts as a whole. Agnesi *et al.* (2019) also strengthens this opinion based on the results of his research which states that STEM-based textbooks can support students' critical thinking skills.

3.2. Data Results of Cognitive Learning Outcomes

Learning outcomes are competencies or abilities that can be achieved by someone after following a certain learning process which includes cognitive, affective, and psychomotor abilities (Nurrita, 2018). In this study, the learning outcomes measured were cognitive, affective, and psychomotor learning outcomes.

Data on cognitive learning outcomes were obtained from the assessment of the pre-test and post-test question sheets. The following is a summary of cognitive learning outcomes data presented in **Table** 5.

Table 5. Summary of Cognitive Learning Outcomes Data

Component	Class			
	Experiment		Control	
	Pre test	***Post test***	***Pre test***	***Pots test***
The Highest Score	69	100	61	100
The Lowest Score	37	81	25	71
Average	52	92,7	45,8	84,6

Based on **Table 5.** it is obtained that the average value of learning outcomes in the cognitive domain in the experimental class is greater than the control class, but further data analysis is needed to determine the difference in significance between the two classes using anacoa analysis. The results of the ANAKOVA hypothesis test are shown in **Table** 6 below.

Table 6. Ancova Hypothesis Test on Cognitive Learning Outcomes

Class	N	Average				F	Sig.
		Pre Test	**Std. Deviation**	***Post Test***	**Std. Deviation**		
Experiment Class	31	52,03	8,84	92,70	4,99	20,64	0,00
Control Class	31	45,83	8,80	84,58	6,42		

Based on the **Table 6.** above, the value of Sig. namely 0.00 <0.05, so that it can be interpreted that H_0 is rejected and H_1 is accepted, namely there is a significant difference in the use of STEM-based textbooks on cognitive learning outcomes between the experimental class and the control class.

3.2.1. The Effect of STEM-Based Textbooks on Biotechnology Subjects on Cognitive Learning Outcomes

Based on **Table 6.** the results of the analysis are 0.00 <0.05 proving that STEM-based textbooks have a significant effect on students' cognitive learning outcomes and the experimental class obtains better learning outcomes compared to the control class. The difference in student learning outcomes in the two classes was due to the fact that in the experimental class students learned to use STEM-based textbooks while the control class used biology textbooks as usual. This statement is in line with the results of Pangesti *et al.* (2017) which states that STEM-based textbooks provide opportunities for students to understand the concept of material better because they have been integrated with the four STEM elements namely Science, Technology, Engineering and Mathematics during learning activities that take place through discussion and practicum activities so that it has implications for improving learning outcomes. student cognitive. According to Fitria and Asrizal (2021) that STEM-based textbooks are effective for improving learning outcomes in cognitive, affective and also psychomotor aspects because students can study with various scientific disciplines directly and systematically.

Increased cognitive learning outcomes are also due to the fact that the textbooks used during learning accommodate up-to-date material according to the student's study area, namely the industrial agricultural area, namely Jember Regency (Hariyadi, 2023). It is also due to the fact that biotechnology material which focuses on technology, engineering, and support for biological agents uses knowledge in the scientific field, then this concept can develop well if it is brought up in learning in harmony with industrial agricultural areas (Siswati, 2020).

Then, the four aspects of STEM namely Science, Technology, Engineering, Mathematics which are contained in textbooks have different functions. Science in a book that contains contextual biotechnology material so that it can lead to building curiosity and openness to new ideas. Technology, contains knowledge about the use of technology in daily activities as an aspect of solving problems in the environment as well as the development of certain new products. Engineering in the form of experiments and knowledge of science in product manufacturing so that students can build on their own experiences and develop more meaningful knowledge skills about the biotechnology material being studied. Meanwhile, Mathematics is shown to evaluate or solve certain problems using calculations of formulas and numbers (Yuanita and Kurnia, 2019). The application of these STEM elements contained in textbooks can make students learn more relevant so as to stimulate the emergence of broader learning experiences and support students to develop their thinking skills and can improve their cognitive learning outcomes (Andaresta, 2021).

3.3. Data Results of Affective Learning Outcomes

Affective learning outcome data were obtained from the assessment of student activity observation sheets during learning. The following is a summary of affective learning outcomes data presented in **Table** 7.

Table 7. Summary of Affective Learning Outcomes Data

Component	Class	
	Experiment	**Control**
The Highest Score	84,375	84,375
The Lowest Score	68,75	65,625
Average	77,9	73,7

Affective learning outcome data have fulfilled the prerequisite test for further analysis using the parametric test using the *Independent Sample T-Test* based on the normal and homogeneous prerequisite test results. Following are the results of the *Independent Sample T-Test* hypothesis test analysis presented in the form of **Table** 8. below:

Table 8. *Independent Sample T-Test* Hypothesis Test on Affective Learning Outcomes

Class	N	Average	Std. Deviation	F	Sig.
Experiment Class	31	77,92	5,07	12,907	0,001
Control Class	31	73,68	5,01		

Based on the **Table** above, the value of Sig. namely 0.001 <0.05, so that it can be interpreted that H_0 is rejected and H_1 is accepted, namely there is a significant difference in affective learning outcomes between the experimental class and the control class.

3.3.1. The Effect of STEM-Based Textbooks on Biotechnology Subjects on Affective Learning Outcomes

Affective learning outcomes or attitudes are obtained from observation sheets of student activity during learning. Based on the analysis of the data, it was found that there were differences in the average learning outcomes of the attitudes of the students in the experimental class and the control class, namely the experimental class obtained a score of 77.9 and the control class of 73.7. Then studied the differences in learning outcomes in the domain of attitudes in the two classes using the *Independent Sample T-Test* to obtain a significance value (2-tailed) of 0.001 <0.05. These results state that the learning outcomes in the attitude domain of the experimental class are better than the

control class. This proves that the use of STEM-based textbooks has a significant effect on learning outcomes in the attitude domain.

The affective learning outcomes measured in this study included a focus on learning, active participation, respect and responsibility. The STEM-based textbooks used during the learning process encourage students to actively participate and focus on paying attention so that there are differences in student learning outcomes with classes that do not use STEM-based textbooks. This statement is in line with the opinion of Zulfa *et al.* (2022) which states that learning using STEM-based textbooks can create fun learning between teachers and students.

The next aspect regarding respect for the elements of Science, Technology, Engineering and Mathematics in student textbooks that have been combined can then help students to teach care for the environment, foster students' creative and innovative souls so as to improve affective learning outcomes or attitudes from students. The reading context that has been understood makes students more sensitive to the conditions around them and respects when there are differences of opinion (Zulfa *et al.* 2022). In line with the opinion expressed by Yulanda and Rahmi, (2022) that the material contained in STEM-based textbooks contains trigger material that can train students to practice problem-solving skills, critical thinking skills, and good communication so that students have high enthusiasm. during the learning process. Thus, the attitude of students in respecting the opinions of other students during discussion activities.

As for the aspect of responsibility according to Muliawan *et al.* (2022) STEM-based textbooks are considered suitable for use in learning because they provide opportunities for students to analyze material themselves in depth on the guidance contained in textbooks so that learning activities run smoothly due to active involvement of students in class. Thus, each student feels they have a responsibility with the same role contribution in solving the problems given tends to increase. Another opinion was conveyed by Fitria *et al.* (2022) in his journal said that the STEM components contained in textbooks that make it easier for students to learn to use the book, and the presentation of teaching materials with good quality in terms of format clarity and equipped with pictures, videos, and other supporting features can improve students' interest in studying the material in the classroom which also has implications for increasing student learning outcomes both in terms of knowledge, attitudes and skills.

3.4. Data Results of Psychomotor Learning Outcomes

Psychomotor learning outcomes data were obtained from the assessment of student activity observation sheets during practicum activities. The following is a summary of psychomotor learning outcomes data presented in **Table 9.**

Table 9. Summary of Psychomotor Learning Outcomes Data

Component	Class	
	Experiment	Control
The Highest Score	96,875	90,625
The Lowest Score	81,25	78,125
Average	89,1	85,7

To analyze data using a parametric test, the data must meet the requirements that it must be normally distributed and homogeneous. After the test was carried out, the result was that the psychomotor learning outcomes data fulfilled the prerequisite test for further analysis using the parametric test using the Independent Sample T-Test. Following are the results of the *Independent Sample T-Test* hypothesis test analysis presented in the form of **Table 10.** below:

Table 10. *Independent Sample T-Test* Hypothesis Test on Psychomotor Learning Outcomes

Class	N	Average	Std. Deviation	F	Sig.

Experiment Class	31	89,11	6,02	20,110	0,00
Control Class	31	85,68	5,19		

Berdasarkan tabel di atas diperoleh nilai Sig. yaitu 0,000<0,05, sehingga dapat diartikan bahwa H_0 ditolak dan H_1 diterima yaitu ada perbedaan yang signifikan hasil belajar psikomotor antara kelas eksperimen dan kelas kontrol.

3.4.1. The Effect of STEM-Based Textbooks on Biotechnology Subjects on Psychomotor Learning Outcomes

Based on the analysis of the data, it was found that there were differences in the average psychomotor learning outcomes of students in the experimental class and the control class, namely the experimental class obtained a score of 89.1 and the control class of 85.7. Then studied the differences in learning outcomes in the skills domain in the two classes using the Independent Sample T-Test so that a significance value (2-tailed) was obtained of 0.00 <0.05. These results state that the learning outcomes of the experimental class are better than the control class. This proves that the use of STEM-based textbooks has a significant effect on learning outcomes in the skills domain.

According to Widodo *et al.* (2021) the difference in skills learning outcomes between the 2 classes is due to the STEM-based textbooks used in the experimental class helping to provide effectiveness to improve skills learning outcomes because the book is equipped with STEM aspects, especially in this case Technology and Engineering. Technology is reflected in the feature of scanning barcodes and inserting videos in books, facilitating students to access supporting materials and visualization videos so that students can fully understand the concept of the material. The Engineering aspect in the book displays a simple experimental design to find a solution which is then conveyed through the provision of practicum activities to train students' skills (Pratiwi and Rachmadiarti, 2022).

STEM-based textbooks can involve students in real contexts so that they are able to support skills learning outcomes through fun, simple variations of experiments that allow students to improve psychomotor learning outcomes (Lukitasari *et al.*, 2022). According to Syafei *et al.* (2019) practicum activities carried out in class can encourage students to improve their skills in discussing, conveying ideas in groups so that learning takes place collaboratively. Students' psychomotor learning outcomes have also increased based on the development of mental processes through aspects of moving muscles so as to shape student skills (Samsuar *et al.*, 2023).

The use of STEM-based textbooks in which experimental designs are contained and then practiced can meet students' needs to learn abstract material concepts to become more concrete (Ate *et al.*, 2022). Thus, it can improve students' psychomotor learning outcomes. This statement was later reinforced by Mawaddah *et al.* (2022) which states that students' skills learning outcomes have increased through the use of STEM-based learning resources so that students feel interested and can be actively involved when learning activities are carried out.

Furthermore, with regard to the integration of scientific disciplines in STEM, it can foster a more meaningful understanding between the principles and concepts of biotechnology material. Students are also trained to collaborate in scientific investigations and problem solving through thinking, learning, and doing directly (Suroto, 2021). Therefore, increasing students' active participation in learning is in line with increasing student skills learning outcomes (Alaini *et al.*, 2022). The problems that are reviewed and used as learning topics are taken from problems that exist in the student's industrial agricultural area itself, so that learning becomes more applicable because the surrounding area is indirectly used as a means of supporting student learning in the classroom. this makes it easier for students to understand the learning that takes place (Damayanti *et al.*, 2021).

4. CONCLUSIONS

Based on the results of the research that has been described, the following conclusions can be obtained: a). There is an influence of STEM-based textbooks on the critical thinking skills of class XII students of SMAN 3 Jember with a Sig (2-tailed) value of 0.00 <0.05 which obtained the highest score of 91.50 in the experimental class with the very high category. b). There is an influence of STEM-based textbooks on the cognitive, affective, and psychomotor learning outcomes of class XII students of SMAN 3 Jember with a Sig (2-tailed) score of 0.00 <0.05 for cognitive learning outcomes that get a score of 100 in the very high category, next namely the value of Sig. 0.001 <0.05 for affective learning outcomes which scored 84.375 in the high category, and 0.00 <0.05 for psychomotor learning outcomes which scored 96.875 in the very high category.

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