STEM-Based Learning Using Assemblr Edu to Improve Students' Critical Thinking Skills; A Case Study in Elementary School

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Abstract: The presence of the 21st century has profoundly demanded a paradigm shift of learning practices to develop the 21st century skills. STEM based learning assisted by Assemblr edu in STEM-based learning can be effective practical implementation to improve students' critical thinking skills. This study aims at investigating the practical use of Assemblr edu to improve students' critical thinking skills in SD Negeri Pagowan 01. This study used quantitative case study. To collect the data, this study used observations and semi-structured interviews. Based on the results of data analysis, it was found that STEM based learning assisted by Assemblr edu had positive effects on the students' critical thinking skills at SD Negeri Pagowan 01. It was evidenced by the students' testing that most students were able achieve critical thinking standards in analyzing driving questions, follow-up questions, collecting information, evaluating information, evaluating arguments, reasoning, providing alternative answers. Moreover, the results of semi-structured interviews showed that most students had positive perceptions on the use of Assemblr edu in STEM-based learning. In short, the practical use of Assemblr edu in STEM-based learning has profoundly improved students' critical thinking skills in SD Negeri Pagowan 01.

Keywords: Assemblr edu; Critical thinking skills; STEM-based learning

Introduction

The presence of the 21st century has demanded a paradigm shift in the learning process that can develop the skills needed. In this case, 21st century learning is oriented towards students' skills known as 4C skills namely critical thinking, creative, communication and collaboration skills (Nurhayati et al., 2024). Nazifah & Asrizal (2022) stated that in this era, students are required to have 21st century skills. In addition, these require students to be able to think critically. According to Arthi & Gandhimathi (2025) critical thinking skills are an important indicator in education in the 21st century, especially in developing the competencies of students in elementary schools.

Furthermore, critical thinking skills can be said to be an important indicator in nowadays learning skills in developing students' skills. These skills deal with a higher-order cognitive process such as: analyzing, evaluating, and synthesizing information in solving complex problems (Rittmann & Mpofu, 2024). These critical thinking skills have a very significant role in encouraging students to solve problems effectively (Ngatminiati et al., 2024). In addition, critical thinking skills are central to the students' process of reflective thinking and cognitive skills at analysis, reasoning, evaluation, and induction (Gusman et al., 2023). Students with critical thinking will help them deal with difficulties they might face in the workplace (Saad et al., 2024).

In addition, based on the results of the latest PISA survey in 2022, students' critical thinking abilities in Indonesia are still below average (Putri et al., 2025). In addition, the critical thinking abilities of elementary school students in Indonesia are still relatively low (Saputra et al., 2024). Lestari et al. (2024) stated that critical thinking skills are an important indicator in PISA to assess students' readiness to face the demands of modern society. Further, the low level of independence of students also plays an important role in the low critical thinking abilities of students (Santika, 2024). This is because independent learning is an effort made to carry out learning activities independently based on one's own motivation to master certain material so that it can be used to solve problems (Asmar & Delyana, 2020).

In regarding the results of the latest PISA survey 2022 above, it indicates that most elementary school students face difficulty developing critical thinking skills. These conditions also occur in SD Negeri Pagowan 01. Most students, in this case, find it difficult to solve complex problems provided in the classroom activities (Hooijdonk et al., 2024). Further, it is found that most teachers have not implemented digitalization in classroom learning. Moreover, developing digital competencies in education is a crucial aspect (Tondeur et al., 2025). Teachers also have not fully implemented STEM-based digital learning in schools (Dhany & Yulianti, 2025). In contrast, learning outcomes must be an output requirement in the learning process (Vaszkun & Szakács, 2025). This ineffective learning process results in lowering students' critical thinking skills during the lesson.

Astuti et al. (2021) stated that digitalization of learning plays an important role in forming students' critical thinking skills. However, the gap in access to technology in learning is a challenge for teachers in facilitating learning encourages students' critical thinking skills. One example of an effort that can encourage critical thinking skills is the use of digital-based learning media. In reality, teachers' low use of digital learning media also affects students' critical thinking abilities. Hanum et al. (2023) added that the lack of comprehensive use of digital learning media can hinder students' critical thinking skills.

In this case, STEM-based learning is one type of learning that is relevant to 21st century learning (Monika et al., 2023). STEM-based learning refers to a learning process that requires students' mindset in technological skills, solving problems, thinking logically and critically and being able to connect knowledge with everyday life (Fauziyah & Wijayanti, 2024). In addition, STEM includes students with various skill sets (engineering, creativity, design, and problem-solving skills (Laseinde & Dada, 2023). It plays an important role in fostering students' critical, creative, innovative, collaborative and communicative thinking abilities (Lestari & Zulyusri, 2022). In this context, critical thinking skills will encourage students to become more independent in solving problems effectively (Khairati et al., 2021).

Several previous studies have studied STEM-based digital learning in improving students' critical thinking skills. Rahma & Wardhani (2024) in her research used critical thinking indicators; truth-seeking, open-mindedness, systematically and inquisitiveness. This study using Virtual lab STEM-based is declared valid and can improve students' critical thinking skills. In contrast, Alfa & Asrizal (2024) found that the application of STEM-based digital learning using Augmented Reality in learning can develop students' critical thinking skills in accordance with the demands of 4C competencies.

Mulyasari & Sholikhah (2021) found that digital learning using STEM-based e-modules has a positive impact on students' critical thinking skills. According to Ikhsan et al. (2025), STEM-PBL digital learning assisted by PhET simulation has significantly improved critical thinking skills of junior high school students. In addition, Eviota & Liangco (2020) also found that integrating online gaming with STEM (PjBL-STEM) can enhance critical thinking skills among junior high school students on the topic of energy and its changes. In short, the findings demonstrate online games into PjBL-STEM provide an effective approach to enhancing 21st-century skills.

Further, previous studies above have examined STEM-based digital learning in improving students' critical thinking skills. However, the researcher finds the gaps that most previous studies deal with improving students' critical thinking skills in junior high school or senior high school. Moreover, the researcher in this study offers novelty in investigating Assemblr edu in STEM-based learning to promote students' critical thinking skills. Assemblr edu is a platform commonly used to create and develop simple augmented reality in educational settings (Handoyo et al., 2024). In addition, this study is significant to provide a significant result of utilizing Assemblr edu as digital platforms dealing with 21st century learning to promote students' critical thinking skills.

To sum up, the researcher in this study deals with the analyzing practical use of Assemblr Edu in STEM-based learning to improve students' critical thinking in elementary school. This study is crucial for teachers in elementary schools since it provides practical references in implementing Assemblr Edu in STEM-based learning to improve students' critical thinking skills in the 21st century.

Method

This study was a quantitative case study. According to Tellis (1997), quantitative case study helps explain the process and outcomes of a phenomenon through complete observation and statistical results. This study used intrinsic case study to understand more about particular case (Copeland, 2014). In addition, intrinsic case study was conducted to analyse the practical implementation of Assemblr Edu in STEM-based learning to improve students' critical thinking skills. To select the sample of study, the researcher used a purposive sampling due to students' characteristic and experience in using Assemblr Edu in the classroom. This study used 24 students from 5th grade students in SD Negeri Pagowan 01, Lumajang.

This study used observation sheet band semi-structured interviews as the research instrument. In collecting the data, the researcher conducted four times observation for two-week observation with a total 8JP. These observations used rubric learning adapted from Dewi & Arifin (2024) dealing with the students' critical thinking skills. In addition, these observations dealt with giving checklist of students' critical thinking skills in analyzing driving questions, analyzing follow-up questions, collecting stated and implied information, evaluating information and evaluating arguments, students' ability in reasoning and providing alternative answers (Dewi & Arifin, 2024). In presenting the results of data analysis this study used descriptive statistical analysis.

In addition, to seek students' perceptions and experiences on the practical use of Assemblr edu during the lesson, the researcher used semi-structured interviews. This was proposed to 10 students as the purposive random sampling to obtain the data of their perceptions and experiences on the practical use of Assemblr edu during to improve their critical thinking skills.

Result and Discussion

This research aims at investigating the practical use of Assemblr Edu in STEM-based learning to improve students' critical thinking skills in SD Negeri Pagowan 01. During the observation, there were 24 students as the participants in the implementation of Assemblr Edu in STEM based learning. Based on the results of observations, the researcher found that students were actively engaged in the learning process using Assemblr Edu in STEM based learning. This is in line with Handoyo et al. (2024) that Assemblr edu can increase the students' engagement in the classroom activities. In this case, the students were more actively motivated in

STEM-based learning conducted in the classroom. This in line with Majid et al. (2023) that Assemblr edu is said to be interesting and interactive learning applications to use at school.

In addition, learning media can be a solution to promote students' learning progress. Assemblr edu, in this case, can stimulate students' active learning (Nafi & Asih, 2024). This is in line with Febriyani et al. (2024) stated that STEM-based learning assisted by Assemblr edu can impact on the improvement of students' outcomes. In addition, Rachmayani & Setyasto (2025) also stated that Assemblr edu has profoundly improved students' outcomes compared to image media used in the teaching-learning process.

Figure 1. Assemblr edu material

In addition, the findings show that there were three standard of critical thinking skills used by the researcher in this study. The percentage of students critical thinking skills is presented below.
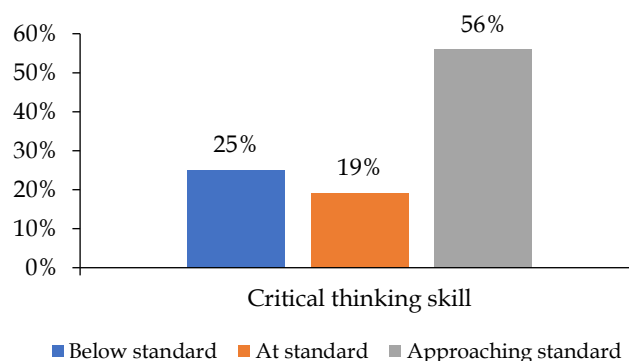

Figure 2. Graph of students' critical thinking skills

Based on the above graph, the researcher categorised the students' critical thinking skills using three standards: below standards, at standard, and approaching standard. It showed that about 56% of students' critical thinking skills in approaching standard. It means that most students have been profoundly able to deal with the indicators of critical thinking skills such as the ability in analyzing driving questions, analyzing follow-up questions, collecting stated and implied information, evaluating information and evaluating arguments, students' ability in reasoning and providing alternative answers.

In addition, there were 25% of students' critical thinking skill in below standard, and 19% of students' critical thinking skill at standard of ability in analyzing driving questions, analyzing follow-up questions, collecting stated and implied information, evaluating information and evaluating arguments, students' ability in reasoning and providing alternative answers. Further, it showed that about a half of students have can think critically in process of STEM-based learning conducted in SD Negeri Pagowan 01.

In this study, the students' critical thinking skills can be analysed through seven indicators of critical thinking skills during the STEM-based learning using Assemblr Edu. These indicators are analysing driving question, asking follow-up questions, collecting information, evaluating stated and implied information, evaluating arguments, reasoning, and providing alternative answers (Dewi & Arifin, 2024). Further, he percentage of students' critical thinking skills indicators is presented as follows.

Table 1. The percentage of critical thinking skills

Indicators	Below standard (%)	At standard (%)	Approaching standard (%)
Analyzing driving question	17	19	64
Follow-up question	23	16	61
Collecting information	14	31	55
Evaluating information	23	29	48
Evaluating arguments	18	24	58
Reasoning	25	22	53
Providing alternative answer	41	12	47

Based on the data presented in Table 1, it showed that about 64% of students have improved their critical thinking skills in analysing driving questions. In addition, it indicates that most students can elaborate answer in driving questions effectively. However, there were about 17% of students in below standard in analysing the driving question. In addition, there were also about 19% of students at standard in analysing the

driving question during the STEM-based learning using Assemblr Edu at SD Negeri Pagowan 01.

Morever, in follow-up questions, there were 23% of students in below standard. It showed that 16% of students are at standard in analysing following-up questions. In contrast, data showed that 61% of students are at approaching standard in analysing following-up questions. It means that most students can answer correctly following-up questions. Further, in collecting information, there were 14% of students below standard category. There were also 31% of students at standard category. Lastly, there were 55% of students are able to collect information based on the collect information category. In addition, in this context, the students are able to collect relevant information based on the topic being discussed in the classroom.

Further, in term of evaluating information, the data shows that there were 23% of students below standard and 29% of students at standard. Meanwhile, there were 48% of students has been approaching standard. It means that most students can recognise any relevant ideas or information and evaluate the relevant information in developing answer the questions. On the other hand, the data showed that most students can evaluate relevant arguments to answer the questions. In this case, there were 58% of students are approaching standard. In addition, there were 24% of students are at standard category. Then, it showed that there were 18% of students can evaluate relevant arguments and categorised below standard.

In terms of reasoning, the data showed that there were 25% of students categorised below standard in reasoning. It indicates that these students are not able to explain the reason in answering related questions. In addition, 22% of students indicated that they were at standard indicating that these students are able in reasoning but there has been inappropriate reasoning dealing with the question. Lastly, there were 53% of students has been approaching standard of reasoning category. It indicates that most students can explain the choices they made when answering questions.

Lastly, the data above showed that 41% of students were below standard in providing alternative answers. It indicates that these students are not able to provide specific alternative answers dealing with the topic. There were 12% of students in the standard category. In addition, 47% of students were categorized to approaching standards since they can provide alternative answers relevant to the topic being discussed.

Furthermore, this study also seeks to investigate students' experience and perception on the practical use of Assemblr Edu in STEM-based learning to promote students' critical thinking. These are examples of students' perceptions on the practical use of Assemblr

Edu in STEM based learning to improve students' critical thinking skills.

Table 2. Students' perception on the use of Assemblr Edu in STEM based learning

Respondents	Perceptions
R1	Assemblr edu help me analysing information.
R2	It is very interesting. We can answer real time in class
R3	It motivates students to be active in quizzes because it is interesting
R4	I can answer some questions correctly
R5	It helps me understand the material about photosynthesis
R6	Assemblr edu can make students active in learning process
R7	It helps me to improve students' critical thinking skill
R8	We can understand more about the photosynthesis in Assemblr edu
R9	We like using Assemblr edu because it can help us to answer the questions more fun
R10	It has materials that help us to collect information more fun

Based on the results of interviews with the students, most students had positive perceptions on the use of Assemblr Edu in STEM based learning. It is stated that most students perceived that Assemblr Edu is interesting application to use in STEM-based learning (Nafi & Asih, 2024). In addition, it is stated that Assemblr Edu also helps them to answer some questions provided by the teacher. In addition, the use of this application in STEM-based learning can improve their critical thinking skills.

The findings showed that the implementation of Assemblr edu in STEM-based learning can improve students' critical thinking skills. There has been improvement in students' critical thinking skills in which most students are able to approach seven indicators of critical thinking skills proposed by Dewi & Arifin (2024). This in line with Febriyani et al. (2024) stated that STEM-based learning assisted by Assemblr Edu has significantly improved students' critical thinking skill. In addition, Valencia & Shodiq (2024) added that students facilitated by Assemblr Edu in STEM based learning enhanced students' critical thinking skills. This confirmed that most students were actively engaged in STEM based learning process using Assemblr edu.

Furthermore, Assemblr edu conducted in STEM based learning is proven to facilitate students learning process effectively. This is in line with Suaib & Sutriyani (2024) stated that Assemblr edu is proven to be augmented learning media to optimize students learning with the critical thinking and problem-solving

skills. In addition, using Assemblr edu provides students with interactive learning process (Handoyo et al., 2024). It helps students to be more motivated and engaged in the learning. Shi et al. (2023) stated that Assemblr edu provides students with interactive activities associated with abstract concept with real objects to support deeper understanding.

Conclusion

Based on the results of data analysis, the findings suggest that most students in SD Pagowan 01 have profoundly improved their critical thinking skills in STEM based learning assisted by Assemblr Edu. In this case, it showed that there has been improvement in students' critical thinking skills based on the seven indicators: analysing driving questions, asking follow-up questions, collecting information, evaluating information, evaluating arguments, reasoning, and providing alternative answers. These improvements are showed in students' passing standard; 64% in analysing driving questions, 61% in follow-up questions, 55% in collecting information, 48% in evaluating information, 58% in evaluating arguments, 53% in reasoning, and 47% in giving alternative answer. In addition, the practical use of Assemblr edu in STEM-based learning has led to students' positive attitudes since it provides interactive, engaging, and more complex activities and materials about photosynthesis in STEM-based learning. Therefore, students are more actively engaged to develop their critical thinking skills related to the topic of photosynthesis in teaching and learning process in SD Pagowan 01. It can be concluded that STEM based learning assisted by Assemblr edu has positive effects on the improvement of students' crictical thinking skills. Integrating technology in STEM-based learning in 21st century learning allows students to seek and analyze the relevant information, discuss, and collaborate with group. In addition, in the implementation of STEM-based learning assisted by Assemblr edu should have appropriate and well-prepared planning, management, and rigorous assessment to improve students' critical thinking skills. In addition, teachers should be able to analyze the students' characteristics and needs as targeted learners before implementation of STEM based learning assisted by Assemblr edu to improve students' critical thinking skills in elementary school.

Author Contributions
M.P.A.K: conceptualization, methodology, formal analysis, investigation, resources, data curation, and writing—

preparation of the original draft; W.: the supervisor of this study conceptualizing the ideas of this study and developing instruments; R.S.D.G.: the supervisor of this study conceptualizing the ideas of this study and reviewing this study.

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Conflicts of Interest

The authors declare no conflict of interest.

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