



Development of a STEM-Based Blog Learning Media on the Human Digestive System to Enhance Students' Critical Thinking Skills and Communication Skills in Secondary Education

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Article Info	Abstract
Keywords: <i>communication skills; critical thinking skills; digital learning media; human digestive system; STEM-based blog;</i>	Background: Students' communication skills and critical thinking abilities in science learning remain relatively low, particularly in the topic of the human digestive system. Therefore, innovative digital learning media, such as STEM-based blogs, are needed to enhance these competencies. Methods: This study employed a Research and Development (R&D) approach using the ADDIE model, which includes analysis, design, development, implementation, and evaluation stages. The participants were 60 eighth-grade students from SMP Islam Nurul I'tishom Bekasi, divided into an experimental group and a control group. Data were collected through expert validation sheets, student response questionnaires, and tests measuring communication and critical thinking skills. Results: The validation results showed that the developed STEM-based blog was feasible, with material and media validation scores of 85% and 80%, respectively. Implementation results indicated that students in the experimental group experienced moderate improvements in communication skills (N-Gain = 0.52) and critical thinking skills (N-Gain = 0.63), while the control group demonstrated low improvement. Student responses to the blog were categorized as good. Conclusion: The STEM-based blog is effective in improving students' communication skills and critical thinking abilities compared to conventional learning methods, and it is suitable for use as a digital learning medium in science education.
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INTRODUCTION

The rapid advancement of digital technology has reshaped educational practices, particularly in secondary education, where learning is increasingly expected to foster conceptual understanding and higher-order skills required in the 21st century. Higher-order skills needed in the

21st century include critical thinking, problem-solving, creativity, communication, and collaboration—competencies deemed essential for students to navigate complex real-world challenges and succeed in an increasingly knowledge-based society (Boholano, 2017; Chalkiadaki, 2018; Ilwandri et al., 2023; Voogt & Roblin, 2012). These higher-order competencies require students to process and analyze information. In addition, they are required to generate new ideas, evaluate evidence, and communicate their reasoning effectively in various contexts (Boholano, 2017; Chalkiadaki, 2018). Critical thinking and communication ability are among the most essential competencies that enable students to analyze information, construct logical arguments, and communicate scientific ideas effectively (Stozhko et al., 2015). These competencies are also closely intertwined with students' scientific literacy, which encompasses the capacity to engage with science-related texts, interpret data, and articulate evidence-based explanations (Amin et al., 2023). Despite these demands, science learning in many secondary classrooms remains predominantly teacher-centered and focused on content delivery, which limits students' opportunities to actively engage in discussion, reasoning, and reflective communication (Ismail et al., 2018). This condition indicates an urgent need for instructional approaches and learning media that support active learning and the development of higher-order skills (Ichsan et al., 2023; Wiyono et al., 2026).

Biology topics related to human body systems, especially the human digestive system, are often perceived as difficult by students due to their abstract processes and complex functional relationships. Learning activities that rely mainly on textbooks and conventional explanations tend to emphasize factual recall instead of analytical thinking, problem-solving, and scientific communication (Huang et al., 2022). Consequently, students frequently experience difficulties in explaining biological mechanisms, defending scientific arguments, and connecting biological concepts with real-life phenomena (Anggraeni et al., 2021). These challenges underscore the importance of designing learning media that can transform abstract biological concepts into meaningful learning experiences while encouraging students to think critically, communicate their understanding clearly, and engage meaningfully with scientific texts (AlAli, 2022).

One instructional approach that has gained considerable attention in addressing these challenges is Science, Technology, Engineering, and Mathematics (STEM) education (Kelley & Knowles, 2016; Dare et al., 2021). STEM-based learning promotes interdisciplinary integration, real-world problem solving, and active student participation through inquiry-based and design-oriented activities (Kelley & Knowles, 2016; Afriana et al., 2021). Through STEM-based blog learning media is an innovative digital platform that integrates Science, Technology, Engineering, and Mathematics components within a web-based blog environment, enabling students to access structured learning materials, engage in interactive activities, and collaborate through digital discussion features (Sumarni & Kadarwati, 2020). This media is specifically designed to promote interdisciplinary learning by embedding STEM principles into biology content, allowing students to explore scientific phenomena while applying technological and engineering thinking skills. As a novel contribution of this study, the STEM-based blog was purposefully developed to simultaneously enhance both critical thinking and communication skills at once. This approach is unique because critical thinking and communication skills are often addressed separately in existing research on learning media. Previously, students are encouraged to explore scientific phenomena, utilize technological tools, and collaboratively construct knowledge (Dare et al., 2021; Ilwandri et al., 2023). However, the effectiveness of STEM education in classroom practice is strongly influenced by the availability of appropriate learning media that facilitate flexible access, structured interaction, and guided exploration aligned with STEM principles (Thibaut et al., 2018).

Alongside the growth of STEM education, blog-based learning media have emerged as a potential digital platform to support student-centered learning (Lloyd, 2021). Blogs enable the

integration of multimedia content, interactive features, and discussion spaces that can enhance student engagement and support asynchronous learning (Endaryati et al., 2021). In the present study, the interactive features included embedded video explanations of digestive system processes, interactive quiz modules using Google Forms integrated within the blog, a comment-based discussion forum for peer-to-peer knowledge sharing, and STEM-integrated problem-solving tasks that required students to connect biological concepts with technological and engineering contexts. Furthermore, blogs provide opportunities for students to express ideas, respond to peers, and participate in written discussions, which are essential for developing communication skills (Ramadina & Rosdiana, 2021). Nevertheless, existing studies predominantly examine the use of blogs or STEM-based blog learning media separately, with limited focus on the systematic integration of blog-based media within a STEM framework, particularly in biology learning contexts at the secondary education level.

This gap in previous research indicates a lack of learning media that explicitly combine STEM principles and blog-based digital platforms to simultaneously enhance students' critical thinking skills and communication ability in learning complex biological topics such as the human digestive system. The novelty of this study lies in the development of a STEM-based blog learning media that is specifically designed to facilitate interdisciplinary learning, interactive discussion, and analytical reasoning within a single digital environment. By emphasizing both cognitive and communicative aspects of learning, this approach offers a distinct contribution compared to existing studies that focus primarily on conceptual understanding and general learning outcomes.

Based on these considerations, this study aims to develop and evaluate the effectiveness of a STEM-based blog learning media on the human digestive system to enhance students' critical thinking skills and communication ability in secondary education. The findings of this study are expected to provide empirical evidence and practical insights for science educators in designing innovative digital learning media that align with 21st-century learning demands and support the effective implementation of STEM-oriented instruction.

METHODS

This study employed a Research and Development (R&D) approach with the primary objective of developing and evaluating a STEM-based blog learning media on the human digestive system. The development process followed the ADDIE model, which consists of five systematic stages: analysis, design, development, implementation, and evaluation. The ADDIE model was selected because it provides a structured framework with a degree of flexibility that allows iterative improvement based on expert validation and field testing results (Molenda, 2003; Rusdi, 2022). The final product of this study was a blog-based learning media integrating STEM principles to support the development of students' critical thinking skills and communication ability.

The research participants consisted of 60 eighth-grade students from SMP Islam Nurul I'tishom Bekasi. The participants were selected using purposive sampling by involving two intact classes to maintain the authenticity of the classroom setting. Class selection was based on equivalent academic performance as evidenced by similar mean scores on the previous semester's science examinations, ensuring that both groups had comparable initial academic levels prior to the study. Class assignment was determined through a lottery method to ensure random and fair group allocation. One class was designated as the experimental group (Class VIII-A, $n = 30$) and received instruction using the STEM-based blog learning media, while the other class (Class VIII-B, $n = 30$) functioned as the control group and was taught through conventional learning methods, including direct instruction and textbook-based activities. Each group comprised 30 students with

relatively comparable academic characteristics based on initial observations conducted prior to the implementation.

The development procedure began with the analysis stage, which aimed to identify curriculum demands, learning objectives, students' characteristics, and common learning difficulties related to the human digestive system topic. The design stage involved structuring the blog layout, organizing learning materials, designing STEM-integrated activities, and preparing discussion tasks intended to stimulate analytical thinking and scientific communication. During the development stage, prior to full validation, a limited testing phase was conducted involving three students from a different class to evaluate the initial usability and readability of the blog. Based on feedback from this limited testing, minor revisions were made to improve the interface and navigational clarity of the media. Subsequently, the revised blog was subjected to validation by two material experts with expertise in biology education and two media experts specializing in educational technology to ensure the accuracy of content, instructional appropriateness, and technical quality. Revisions were made based on expert suggestions before the learning media was implemented in the classroom. The implementation stage involved the use of the revised blog in the experimental class, while the evaluation stage focused on assessing the feasibility, student responses, and effectiveness of the developed learning media.

Data were collected using several instruments, including expert validation sheets, student response questionnaires, and written essay tests designed to measure both critical thinking skills and communication ability. Communication ability was assessed through written essay tests that required students to explain biological processes, construct scientific arguments, and present evidence-based reasoning in written form, following the indicators proposed by Samosa (2021). The expert validation, which also involved two experienced science teachers from SMP Islam Nurul I'tishom Bekasi as practitioner validators, sheets were used to evaluate the feasibility of the learning media in terms of content quality, presentation, and technical aspects. The student response questionnaire was administered to examine students' perceptions regarding the usability, attractiveness, and contribution of the blog to the learning process. To measure learning improvement, tests of critical thinking skills and communication ability were administered as pre-tests and post-tests to both the experimental and control groups. All test instruments were reviewed by experts to ensure content validity and alignment with the learning objectives. The feasibility of the STEM-based blog learning media was determined based on expert validation scores, which were calculated using the following formula (Akbar, 2021; Rusdi, 2022):

$$\text{Validity Percentage} = \frac{\text{Obtained Score}}{\text{Maximum Score}} \times 100\%$$

The resulting percentages were interpreted according to predefined feasibility criteria, as presented in Table 1.

Table 1. Criteria for Learning Media Feasibility

Percentage (%)	Category
81–100	Very Feasible
61–80	Feasible
41–60	Moderately Feasible
21–40	Less Feasible
≤ 20	Not Feasible

The effectiveness of the learning media in improving students' critical thinking skills and communication ability was analyzed using the normalized gain (N-Gain) method (Hake, 1999). The N-Gain score was calculated based on pre-test and post-test results using the following formula:

$$\text{N-Gain} = \frac{\text{Post-test Score} - \text{Pre-test Score}}{\text{Maximum Score} - \text{Pre-test Score}}$$

The N-Gain values were then classified into improvement categories, as shown in **Table 2**.

Table 2. N-Gain Classification Criteria

N-Gain Value	Category
$g \geq 0.70$	High
$0.30 \leq g < 0.70$	Moderate
$g < 0.30$	Low

Descriptive statistical analysis was employed to summarize the results of expert validation, student responses, and learning outcomes. The N-Gain scores of the experimental and control groups were compared to determine the effectiveness of the STEM-based blog learning media in enhancing students' critical thinking skills and communication ability. To strengthen the analysis, an independent-samples t-test was also conducted to determine whether the difference in N-Gain scores between the experimental and control groups was statistically significant ($p < 0.05$), thereby providing a more rigorous basis for concluding the media's effectiveness.

RESULT AND DISCUSSION

The feasibility of the developed STEM-based blog learning media was evaluated through expert validation involving material experts and media experts (Akbar, 2021). The developed blog media featured several key components, including embedded video explanations of digestive system processes, interactive quiz modules via Google Forms, a peer discussion forum, and STEM problem-solving tasks connecting biology with technology and engineering. [Note: Images of the developed media product, including screenshots of the blog interface, learning modules, and interactive features, are recommended to be included here to provide visual documentation of the media.] The validation results demonstrated that the learning media met the required standards for instructional use, supported by engaging features including embedded video explanations of digestive system processes, interactive quiz modules integrated via Google Forms, a peer discussion forum for collaborative learning, and STEM problem-solving tasks that connected biological concepts with real-world technological and engineering contexts (Rusdi, 2022). The material expert validation yielded a feasibility score of 85%, categorized as very feasible, while the media expert validation resulted in a score of 80%, categorized as feasible. These findings indicate that the content accuracy, instructional design, and technical quality of the blog were appropriate to support learning about the human digestive system (Larasati et al., 2021). The high material validation score (85%) was primarily attributed to the accurate alignment of the blog content with the curriculum objectives, the clarity of biological concept explanations, and the inclusion of real-life examples connecting digestive system functions with students' daily experiences. The media validation score (80%) reflected the well-organized layout, intuitive navigation, and the effective integration of multimedia elements that facilitated self-directed learning.

Table 3. Expert Validation Results of the STEM-Based Blog Learning Media

Validator Type	Validation Score (%)	Category
Material Expert	85	Very Feasible
Media Expert	80	Feasible

The high feasibility scores suggest that the integration of STEM components within a blog-based learning environment can be effectively designed to meet curriculum demands and student learning characteristics (Fauzi & Hayya, 2022; Suryawati & Osman, 2018). This finding aligns with research by Saad & Fuad (2021), who reported that learning media developed through systematic instructional design models tend to demonstrate high validity and instructional suitability. Previous studies also show that STEM-based learning media support interdisciplinary learning and enhance conceptual understanding in science education (Mutakinati et al., 2018; Wahono & Chang, 2020; Harianto et al., 2026).

Student responses were analyzed to assess the practicality and acceptance of the developed learning media. The results indicated that students responded positively, with an average response score of 3.47 out of 4.00, which falls into the good category (Larasati et al., 2024). Several factors contributed to the positive student responses. First, the blog's flexible and accessible digital format allowed students to learn at their own pace, which reduced anxiety and increased learning confidence. Second, the multimedia features such as videos and interactive quizzes made abstract biological concepts more concrete and visually engaging. Third, the discussion forum provided a low-pressure environment for students to express scientific ideas and receive peer feedback, which fostered a sense of community in learning. The highest response scores were related to students' participation in group discussions and their ability to express ideas through the blog platform (Rahman et al., 2023).

Table 4. Student Response Results toward the STEM-Based Blog Learning Media

Evaluated Aspect	Mean Score	Category
Ease of Use	3.45	Good
Attractiveness	3.42	Good
Learning Engagement	3.50	Very Good
Communication Support	3.52	Very Good
Overall Average	3.47	Good

These findings indicate that the blog-based learning media successfully facilitated student engagement and interaction (Ramadina & Rosdiana, 2021). The embedded discussion features in the blog encouraged students to share opinions, respond to peers, and articulate scientific explanations (Khairani et al., 2023). This result aligns with previous research by Usman et al. (2024), which suggests that interactive digital platforms promote active learning and improve students' communication skills, specifically in areas of written scientific explanation, construction of logical arguments, and the ability to convey evidence-based reasoning in biology learning contexts, by providing spaces for collaborative discussion and reflection (Endaryati et al., 2021; Lloyd, 2021).

The improvement of students' communication skills was analyzed using the normalized gain (N-Gain) method based on pre-test and post-test results (Hake, 1999). To strengthen the statistical analysis, an independent-samples t-test was also conducted, yielding $t(58) = 6.34$, $p < 0.05$, confirming that the difference in N-Gain scores between the experimental and control groups was statistically significant. The effect size (Cohen's $d = 0.87$) indicated a large practical effect, further supporting the effectiveness of the STEM-based blog in improving communication skills. The experimental group achieved an N-Gain score of 0.52, categorized as moderate, while the control group obtained an N-Gain score of 0.12, categorized as low. This indicates that students

who learned using the STEM-based blog experienced greater improvement in communication skills compared to those taught using conventional methods (Sumarni & Kadarwati, 2020).

Table 5. N-Gain Results of Students' Communication Skills

Group	Pre-test Mean	Post-test Mean	N-Gain	Category
Experimental	62.40	82.10	0.52	Moderate
Control	64.10	68.50	0.12	Low

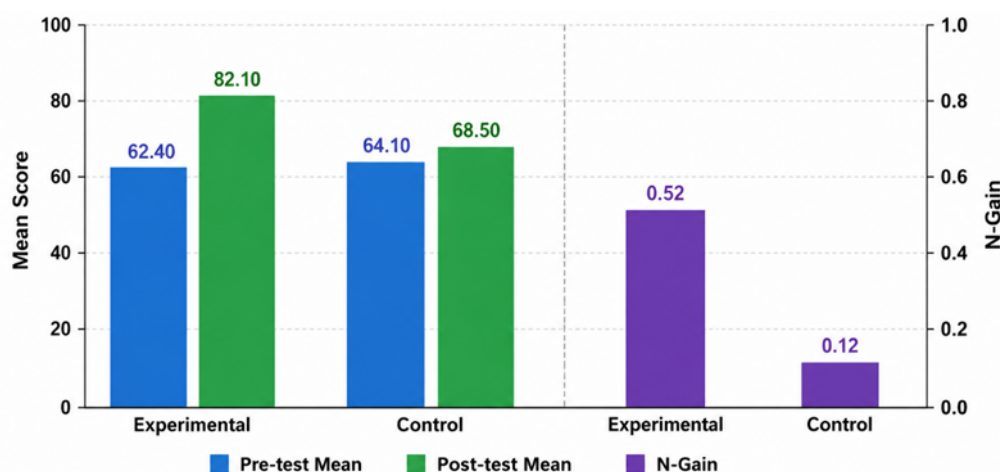


Figure 1. Comparison of N-Gain Communication Skills between Groups

The observed improvement in communication skills, assessed using four indicators: (1) clarity of biological process explanation, (2) logical argument construction, (3) use of scientific evidence in written responses, and (4) coherence and organization of written communication can be attributed to learning activities that required students to explain biological processes, participate in discussions, and present arguments in written form. This finding is consistent with research by Wahono et al. (2020), which indicates that STEM-oriented learning environments effectively enhance students' higher-order skills including the ability to communicate scientific ideas through structured interaction and discourse (Dare et al., 2021; Stozhko et al., 2015).

Students' critical thinking skills were also evaluated using N-Gain analysis (Rahmadita et al., 2021). To supplement the N-Gain analysis with inferential statistical evidence, an independent-samples t-test was performed on the critical thinking post-test scores, yielding $t(58) = 7.12$, $p < 0.05$, indicating a statistically significant difference between groups. The effect size (Cohen's $d = 0.92$) reflected a large practical effect, further confirming the superiority of the STEM-based blog approach. The experimental group achieved an N-Gain score of 0.63, categorized as moderate, whereas the control group achieved an N-Gain score of 0.21, categorized as low. These results indicate that the STEM-based blog learning media was more effective in fostering students' critical thinking skills than conventional instruction (Lestari & Widodo, 2023).

Table 6. N-Gain Results of Students' Critical Thinking Skills

Group	Pre-test Mean	Post-test Mean	N-Gain	Category
Experimental	60.30	85.20	0.63	Moderate
Control	61.00	69.10	0.21	Low

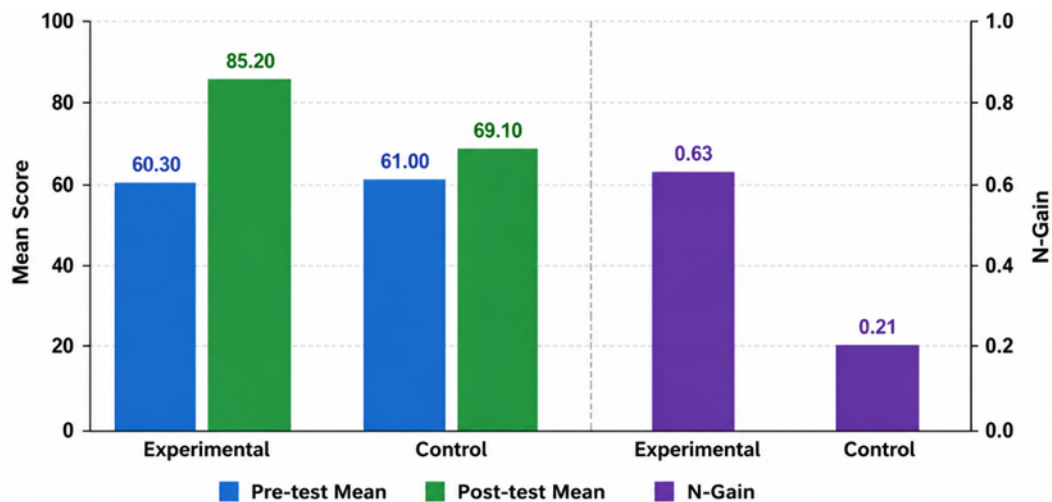


Figure 2. Comparison of N-Gain Critical Thinking Skills between Groups

The observed improvement in critical thinking skills is likely due to the STEM-integrated tasks that specifically engaged each component of STEM: in the Science component, students investigated the mechanisms and disorders of the digestive system; in the Technology component, they utilized the blog platform and digital quiz tools to access and interact with content; in the Engineering component, students designed simple solutions for digestive health problems using scientific principles; and in the Mathematics component, they analyzed nutritional data and calculated dietary requirements related to digestive health (Kelley & Knowles, 2016; Afriana et al., 2021) tasks embedded in the blog, which required students to analyze digestive system mechanisms, relate scientific concepts to real-life situations, and apply interdisciplinary reasoning (Afriana et al., 2021). This finding supports previous research by Mutakinati et al. (2018), which indicates that STEM-based learning environments promote higher-order thinking skills, including critical thinking, by engaging students in inquiry-based and problem-solving activities (AlAli, 2022).

Overall, the results demonstrate that the STEM-based blog learning media is feasible, well-received by students, and effective in enhancing both communication skills and critical thinking abilities. Compared to conventional learning approaches, the STEM-based blog provided a more interactive approach as it incorporates four key interactive features: (1) embedded video explanations of digestive system processes that supported visual learning, (2) Google Forms-based quiz modules with immediate feedback for formative self-assessment, (3) a comment-based peer discussion forum that promoted collaborative knowledge construction, and (4) STEM-integrated problem-solving tasks requiring students to apply interdisciplinary reasoning in real-life contexts, student-centered learning environment that supported active engagement and deeper understanding of the human digestive system (Ismail et al., 2018). These findings are consistent with research by Wahono et al. (2020), which demonstrates that integrated STEM learning approaches contribute positively to the development of students' 21st-century skills including higher-order thinking and communication competencies (Chalkiadaki, 2018). Therefore, the STEM-based blog learning media developed in this study can be considered a viable alternative for science instruction in secondary education, particularly for complex biological topics (Suryawati & Osman, 2018).

CONCLUSION

Based on the findings of this study, it can be concluded that the STEM-based blog learning media developed for the human digestive system topic is feasible, practical, and effective for biology learning, specifically within the human digestive system topic in secondary education. Expert validation results indicate that the media meets instructional standards in terms of content

accuracy, instructional design, and technical quality, while student responses show positive perceptions regarding ease of use, attractiveness, and support for learning engagement and communication. The effectiveness of the media is evidenced by a moderate improvement in students' communication skills and critical thinking skills in the experimental group compared to the low improvement in the control group. These results highlight the novelty of integrating STEM-oriented learning activities within a blog-based digital platform, which facilitates interactive discussion, written scientific communication, and interdisciplinary reasoning. Therefore, this learning media provides a more interactive and meaningful learning experience in comparison to the conventional instruction. This learning media can also serve as an effective alternative for teaching complex biological concepts. Future research is recommended to implement this media in broader contexts and explore its impact on other higher-order thinking skills.

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