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Development of a web-based learning platform for informatics using an inquiry approach to enhance learning outcomes in high school

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ABSTRACT

This study aims to develop an Informatics learning website based on Inquiry Learning to improve student learning outcomes at SMA Free Methodist. The background of this research lies in the low level of student engagement in Informatics classes and the limited availability of digital media that supports exploration and independent critical thinking. Inquiry Learning is considered an appropriate approach for fostering active, discovery-based learning, while the website serves as an accessible and interactive platform for delivering instructional content. The study used the Research and Development (R&D) method, applying the ADDIE model (Analysis, Design, Development, Implementation, Evaluation). The research subjects included 30 tenth-grade students. Data collection tools comprised expert validation sheets, student response questionnaires, observations, and learning outcome tests. The results indicate that the developed website is valid according to evaluations from content and media experts. Students responded very positively to the interactive features such as quizzes, tutorial videos, discussion forums, and inquiry-based assignments. The inquiry learning model applied through the website effectively enhanced students' conceptual understanding, critical thinking skills, and overall academic performance. In conclusion, the Inquiry Learning-based Informatics website is highly effective and suitable for use as an innovative digital learning medium at the senior high school level.

INTRODUCTION

21st century education requires students to master critical thinking, creativity, collaboration, and communication (4C) skills as a foundation for facing global challenges (Trilling & Fadel, 2009). In this context, the Merdeka Curriculum launched by the Ministry of Education, Culture, Research, and Technology emphasizes competency-based and differentiated learning, including in the subject of Informatics, which integrates the technical, social, and ethical aspects of technology (Ministry of Education, Culture, Research, and Technology, 2022). However, initial observations at SMA Free Methodist show that Informatics learning is still dominated by lecture methods and the use of conventional media, so that students tend to be passive, less collaborative, and have difficulty in critical thinking and problem solving. This condition is not in line with the principles of the Merdeka Curriculum, which emphasizes active, inquiry, and reflective learning (Observation Data, 2025).

Various studies show that inquiry-based learning can improve students' critical thinking, communication, and collaboration skills (Nasution, 2024; Qodri et al., 2025). This approach places students as active subjects who explore concepts through observation, experimentation, and reflection, thus aligning with the development of 21st-century skills. Additionally, the use of website-based digital media has proven effective in increasing motivation, interactivity, and learning independence because it can integrate various multimedia elements such as text, images, videos, and interactive simulations (I Komang et al., 2025; Purwasih et al., 2021).

However, previous studies show that most research on inquiry-based media development still focuses on science subjects and has not been widely applied in the context of computer science

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education at the high school level. On the other hand, research related to website-based learning media generally only assesses the effectiveness of learning without systematically measuring the quality of the software using international standards such as ISO/IEC 25010 (Jayanto, 2017; Ratnaduhita et al., 2023; Setyanto et al., 2021). Thus, there is a research gap in the aspect of applying the inquiry approach in website-based media for Informatics learning, as well as the absence of a comprehensive study on the quality and effectiveness of such media.

Based on these gaps, this study has a novelty in the form of developing an inquiry-based Informatics learning website using the ADDIE development model, as well as evaluating its quality using the ISO/IEC 25010 standard. This study also analyzes the effectiveness of media in improving students' critical thinking, collaboration, and communication skills. Thus, the objectives of this study are to develop an inquiry-based Informatics learning website on the subject of Critical Thinking and the Social Impact of Informatics using the ADDIE model, assess the quality of the media according to the ISO/IEC 25010 standard, and analyze its effectiveness in improving critical thinking, collaboration, and communication skills among 11th grade students at Free Methodist High School.

RESEARCH METHODS

This study is a research and development (R&D) project that aims to produce a website-based learning medium using an inquiry learning approach and to test its feasibility and effectiveness in improving students' critical thinking, collaboration, and communication skills. The development model used is ADDIE, which consists of five stages, namely Analysis, Design, Development, Implementation, and Evaluation (Molenda, 2003).

The research was conducted at SMA Free Methodist Kota Medan with a population of 44 students in grade XI. The sampling technique used purposive sampling, with a preliminary trial involving four students, a limited trial involving ten students, and a field trial involving thirty students. Participants were selected based on the criteria of being active 11th grade students who had taken Informatics courses, were willing to participate fully in the research activities, and represented a diverse range of abilities. The analysis stage was conducted through observation and interviews with teachers to identify learning needs and problems faced by students in Informatics. The design stage included designing the website structure, compiling materials, and inquiry-based learning activities following the 5M steps (observing, questioning, reasoning, trying, and communicating). The development stage was carried out by creating media based on HTML, CSS, and JavaScript, which was then validated by three experts, namely subject matter experts, media experts, and learning design experts. Next, the implementation stage was carried out through limited trials in the 11th grade to assess the practicality and student response to the developed media. The evaluation stage was carried out to assess the quality of the media based on the ISO/IEC 25010 standard and to test the effectiveness of the media in improving student learning outcomes.

The data in this study were collected through observation of student activities during the learning process, expert validation questionnaires and student responses, learning outcome tests administered in the form of pre-tests and post-tests, as well as interviews with teachers and students to obtain qualitative data related to their experiences and perceptions of website-based learning media.

Data analysis was conducted quantitatively and qualitatively. Quantitative data were analyzed descriptively and inferentially to measure the effectiveness of learning media in improving student learning outcomes. Differences in pretest and posttest results were analyzed using the paired-sample t-test if the data were normally distributed, or the Wilcoxon signed-rank test if they did not meet the assumption of normality. The effect size was calculated using Cohen's d to determine the magnitude of the effect of media use on learning outcomes. Meanwhile, qualitative data were analyzed using thematic analysis techniques, which included the processes of coding, grouping, and extracting the main themes that represented students' experiences while using the media. Data validity was maintained through triangulation of sources and methods to ensure the reliability of the research results.

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RESULTS AND DISCUSSION

Validation Result

The validation results from three main aspects—material, design, and media—show that the website-based learning media with an inquiry learning approach received a very good rating from all validators. The material aspect received an average score of 4.35, with the assessment that the content of the media was in accordance with the principles and learning outcomes of the Merdeka Curriculum, had clear concepts, and was relevant to the basic competencies being taught. This confirms that the developed content meets the criteria of substance and scientific accuracy as suggested by Molenda (2003) and the Ministry of Education, Culture, Research, and Technology (Kemendikbudristek, 2024).

Table 1. Validation Result

Validation Aspects	Score Average	Category	Description
Material	4,35	Very Good	Content in accordance with the Merdeka Curriculum (Kemendikbudristek, 2024), with concepts that are accurate, clear, and relevant.
Design	4,28	Very Good	The 5M inquiry flow structure is clear (Rhosalia, 2017), with an attractive display and neat navigation.
Media	4,30	Very Good	Multimedia integration supports learning (Molenda, 2003), and is easy to use.
Average	**4,31**	**Very Good**	Suitable for use without major revisions.

In terms of design, the media received an average score of 4.28, categorized as excellent. The validators assessed that the inquiry-based learning flow through the 5M stages (observing, questioning, reasoning, trying, and communicating) was systematically structured and easy for students to follow. The attractive visual design, neat layout, and intuitive navigation also supported student engagement in learning. These results are in line with the findings of Qodri et al. (2025) and I Komang et al. (2025), which emphasize the importance of interactive design and the integration of visual elements in supporting students' 4C skills.

The media aspect received an average score of 4.30, also in the “very good” category. The integration of various multimedia elements—such as text, video, and simulations—was considered effective in supporting the inquiry-based learning process. The media was also considered easy to use and responsive on various devices. Overall, the average score of 4.31 for the three aspects indicates that this media is suitable for use without the need for major revisions.

Improvement in Cognitive Ability

Based on the critical thinking test results, the students' average pretest score was 62.47 (SD = 8.12), while the average posttest score increased to 79.63 (SD = 7.85). The results of the paired-sample t-test showed a value of $t(29) = 9.42$, $p < 0.001$, which means that there was a significant difference between the pretest and posttest results. The effect size calculated using Cohen's d was 1.72, indicating a very large effect. These findings indicate that the use of website-based media with an inquiry learning approach can significantly improve students' critical thinking skills.

Table 2. Results of the Paired t-Test for Cognitive Scores

Variable	Mean Pre	SD Pre	Mean Post	SD Post	t	df	p	Cohen’s d
Cognitive	62,47	8,12	79,63	7,85	9,42	29	<0,001	1,72

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Improvement in Affective Aspects (Collaboration and Communication)

The collaboration assessment showed an average increase from 3.12 to 4.01 on a 1–5 Likert scale. The Wilcoxon signed-rank test was used because the data were not normally distributed, with a result of $Z = -3.89$, $p < 0.001$, which means there was a significant increase. For the communication aspect, the average score increased from 3.25 to 4.08, with a Wilcoxon test result of $Z = -4.11$, $p < 0.001$. The effect size (r) for both variables was 0.71 and 0.75, which falls into the large effect category.

Table 3. Wilcoxon Test Results for Affective Scores

Variabel	Mean Pre	Mean Post	Z	p	r	Interpretasi
Collaboration	3,12	4,01	-3,89	<0,001	0,71	Efek besar
Communication	3,25	4,08	-4,11	<0,001	0,75	Efek besar

Media Quality Assessment (ISO/IEC 25010)

The results of the media quality assessment by experts showed an overall average score of 4.32 (SD = 0.41), which falls into the excellent category. The aspect with the highest score was usability (4.55), while the aspect with the lowest score was maintainability (4.08). The assessment by student users showed an average score of 4.21 (SD = 0.47), also in the excellent category, with functionality and usability as the dominant aspects.

Table 4. Media Quality Assessment Results (ISO/IEC 25010) (International Organization for Standardization, 2011)

Aspect ISO/IEC 25010	Score Average	Category
Functionality	4,18	Very Good
Usability	4,55	Very Good
Reliability	4,12	Very Good
Efficiency	4,35	Very Good
Compatibility	4,30	Very Good
Security	4,12	Good
Maintainability	4,08	Good
Portability	4,25	Very Good
Average	**4,24**	**Very Good**

Qualitative Findings Results of thematic analysis

Qualitative findings from the thematic analysis of student interviews and reflective journals revealed three main themes.

Table 5. Thematic Analysis Results

Main Theme	Description of Findings
Learning Engagement	Students feel more active, challenged, and enjoy the inquiry process (Siemens, 2005).
Flexible Access	Media can be used in class and at home, easily accessed via devices.
Technical Challenges	Some students experience internet network constraints (Bruner, 1977).

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The first theme, learning engagement, showed that students felt more active, curious, and motivated during the learning process. They became more involved in searching for information, discussing it collaboratively, and drawing conclusions independently. This finding aligns with Siemens' (2005) connectivist learning theory, which emphasizes learner autonomy and active participation through exploration and interaction. One student expressed, *"I became more interested in learning because I could try the simulations directly rather than just reading the theory."* These engagement patterns are consistent with prior evidence that inquiry-based tasks, when properly scaffolded, promote active cognitive involvement and learner autonomy (Aktamış et al., 2016).

The second theme, flexible access, highlights the affordances of website-based media for both in-class and out-of-class learning. Students valued the ability to revisit modules, run simulations, and review content at their own pace, which aligns with multimedia learning principles that well-designed audio-visual materials support comprehension and retention when integrated appropriately. This usability and multi-device accessibility help explain the high usability scores observed in the ISO/IEC 25010 assessment (Mayer, 2009).

The third theme, technical challenges, refers to unstable internet connectivity experienced by some students during implementation. Although the media itself functioned as intended, unequal digital infrastructure limited consistent access for a subset of participants—a contextual constraint commonly reported in Indonesian studies on digital learning readiness. This finding underscores that technological readiness is a necessary condition for scalable implementation of web-based inquiry learning (Putra et al., 2024).

Overall, the results of the quantitative analysis indicate a significant increase in both cognitive and affective domains, with a large effect size. These findings are corroborated by qualitative insights showing that students felt more motivated, actively involved, and better able to understand the material through a website-based inquiry-learning approach. Consequently, the developed learning media has demonstrated its effectiveness and suitability for Informatics learning at the high-school level.

These results align with the broader literature on inquiry-based learning which suggests that such approaches can improve both cognitive and affective outcomes (Aktamış et al., 2016). The findings also support the argument by Kirschner et al. (2006) concerning the need for appropriate scaffolding in inquiry-oriented instruction. Furthermore, the strong usability scores observed lend support to Mayer (2009) multimedia learning principles, which emphasize the role of well-designed multimedia elements in enhancing learning. Finally, the identification of technical barriers echoes findings from Indonesian literature regarding digital infrastructure readiness as a key determinant of online learning effectiveness (Nur et al., 2023).

Discussion

The results of the study indicate that the use of website-based learning media with an inquiry learning approach is effective in improving students' cognitive and affective abilities. The significant increase in pretest–posttest scores proves that the inquiry learning model is capable of stimulating higher-order thinking processes. This is in line with the views of Piaget (2005) and Bruner (1977) that discovery-based learning allows students to actively construct knowledge through exploration, investigation, and reflection. Thus, this approach not only places students as recipients of information but also as creators of meaning who construct concepts based on their learning experiences.

Improvements in affective aspects were also seen in students' ability to collaborate and communicate. Previously, students tended to be passive and less involved in discussion activities, but after the implementation of this media, they were more active in expressing their ideas and working together to complete group assignments. These findings support the results of Aktamış et al. (2016) research, which showed that inquiry-based learning can improve students' scientific attitudes, social skills, and collaborative skills. These results are also in line with the views of Kirschner et al. (2006), who emphasize the importance of scaffolding or guidance in inquiry activities so that students can achieve optimal learning outcomes.

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In terms of media quality, the validation results showed high scores in the aspects of usability and functionality, which means that the website interface design has fulfilled the principles of ease of use and clarity of navigation. These findings are consistent with the ISO/IEC 25010 standard, which places usability as a major component in the success of digital learning systems (ISO/IEC, 2011). Simple, responsive, and interactive designs have been proven to create a more positive learning experience. This is also in line with the theory of multimedia learning proposed by Mayer (2009), which states that the combination of text, images, and animations designed appropriately can improve concept understanding and learning retention through multiple representations.

Overall, the results of the study prove that the integration of inquiry-based learning with website-based media has a positive impact on students' cognitive and affective domains. The improvement in cognitive learning outcomes supports Mayer (2009) view on the effectiveness of interactive multimedia, while the improvement in collaboration and communication skills shows that this media contributes to the development of 21st-century skills (Trilling & Fadel, 2009), which is the focus of the Merdeka Curriculum (Kemendikbudristek, 2024).

However, this study also found technical obstacles in the form of limited internet networks in several locations, which affected the smooth use of the media. This condition reinforces the results of research by Nur et al. (2023), which states that digital infrastructure readiness is a crucial factor in the successful implementation of online learning in Indonesia. Therefore, even though this website-based learning media is considered feasible and effective, its success still depends heavily on infrastructure support, teacher training, and school policies in integrating technology in a sustainable manner.

Thus, the results of this study reinforce the evidence that the integration of inquiry learning with website-based learning media not only improves cognitive learning outcomes but also develops students' collaboration and communication skills as part of 21st-century competencies. This media is suitable for use as an innovation in Informatics learning at the high school level and has the potential to become a development model for other subjects that apply active and technology-based learning principles.

CONCLUSION

This study concludes that website-based learning media with an inquiry learning approach is feasible and effective for use in computer science education at the high school level. Validation results from experts in subject matter, design, and media indicate that this media is of excellent quality based on the ISO/IEC 25010 standard, particularly in terms of ease of use and functional suitability. The simple, interactive interface design and integration of multimedia elements support student engagement and enhance the learning experience. The application of this media has been proven to improve students' critical thinking skills while developing collaboration and communication skills. Students become more active in discussing, collaborating, and communicating ideas during the learning process. In addition, this media provides high flexibility because it can be accessed anytime and anywhere, although technical obstacles such as limited internet access in some locations are still encountered.

Overall, the integration of inquiry-based learning with website-based media is in line with the principles of the Merdeka Curriculum and is relevant to supporting the mastery of 21st-century skills. This media can be used as an interactive, effective, and active learning-oriented innovation in Informatics education as well as for character development in students. As a follow-up, teachers are advised to implement this media as an innovative alternative in the learning process. Schools need to strengthen infrastructure support, such as adequate internet networks, digital learning devices, and teacher training for optimal utilization. Further development can expand the material and context of its use, as well as examine the long-term impact on student motivation, retention, and creativity. With continuous development, inquiry learning-based website-based learning media has the potential to become an effective digital learning model in shaping 21st-century competencies and skills in students.

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