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Development of a Digital Literacy Based E-Module in Informatics Subject to Improve Student Learning Outcomes

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Abstract: This study aims to design and develop a digital literacy-based e-module for the Informatics subject to improve student learning outcomes at MTsN 3 Langkat. The developed module aims to: (1) Determine the feasibility of the e-module; (2) Determine the practicality of the e-module; (3) Determine the effectiveness of the e-module; (4) Identify the differences in student learning outcomes between those who use the digital literacy-based e-learning module and those who use conventional modules; (5) Identify differences in learning outcomes based on visual, auditory, and kinesthetic learning styles; and (6) Examine the interaction between the digital literacy-based e-learning module and learning styles in influencing student learning outcomes. The population of this study includes all eighth-grade students at MTsN 3 Langkat. The sampling technique used is cluster random sampling. The research design employed is a 2x3 factorial design, and the data analysis technique used is two-way analysis of variance (ANOVA). This study obtained the results of the e-module which was feasible, practical, effective, there were differences in learning outcomes in the module groups, learning styles and there was interaction.

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Introduction

Digital literacy is one of the essential skills for using information and communication technology effectively, appropriately, and productively. Based on the 2022 national digital literacy data published on the Ministry of Communication and Information Technology website, the measurement refers to the Digital Literacy Roadmap 2020–2024 (Kominfo, 2022), which includes four pillars: Digital Skill, Digital Ethics, Digital Safety, and Digital Culture. The national digital literacy index scored 3.54 out of a maximum score of 5. The Digital Culture pillar achieved the highest index at 3.84, while Digital Safety received the lowest at 3.12.

The Informatics subject also aims to enhance students' ability to maximize their potential in the digital world through digital skills, ethical behavior in the digital space, and the application of Pancasila values in digital culture, as well as the ability to live safely and in balance in the digital environment. Informatics learning requires the use of digital technologies such as mobile phones, computers, software or applications, the internet, and other devices. Students develop skills in using information and communication technology, while the teacher's role is to facilitate the teaching and learning process by delivering

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materials, providing examples, and offering students opportunities to practice using software or hardware. As a result, students build practical skills in using information technology, problem-solving, programming, and more.

MTsN 3 Langkat is one of the schools/madrasahs in Langkat Regency that includes Informatics in its curriculum, as outlined in the structure of the Merdeka Curriculum. Based on field surveys and feedback from subject teachers, it was found that students' learning outcomes in Informatics are considered low, with an average score of 72, while the competency standard score is set at 76 or higher. The low scores can be analyzed using Reigeluth's learning variables, which include learning conditions, learning methods, and learning outcomes. These variables help identify contributing factors such as the characteristics of the subject, student characteristics, the use of inappropriate learning models or strategies by the teacher, and learning resources like teaching materials that may not align with students' needs.

From interviews with Informatics teachers about the learning challenges students face, it was found that the teaching materials used—namely printed Informatics textbooks—were considered unsuitable for students' characteristics and learning styles. Based on diagnostic assessments to identify student characteristics, it was revealed that many students struggle with abstract thinking and complex concepts. This means they find it easier to learn concrete concepts rather than abstract ones. Additionally, they are not yet able to learn independently or take full responsibility for their learning, and they have not shown a strong interest in technology. These factors contribute to the low learning outcomes in the Informatics subject.

In relation to students finding it easier to learn concrete material than abstract content, Dale (1969) proposed a theory known as the Cone of Experience, which represents a continuum from concrete to abstract experiences. According to this theory, students benefit from learning activities that are concrete, involving direct experience with real objects, events, or phenomena. In such learning, students are actively engaged in solving problems based on predetermined learning objectives (Dale, 1969).

Currently, MTsN 3 Langkat does not yet have effective media, learning modules, or teaching materials that can enhance students' understanding through direct experience, which could be beneficial during the learning process and positively impact learning outcomes. Although several studies have been conducted on the development of digital literacy-based teaching materials or learning modules, most of them have not employed varied research and development methods and have only reached the feasibility testing stage, without continuing to effectiveness testing that focuses on measuring student learning outcomes after using the developed materials.

Therefore, this study needs to employ a different research and development method, test it in a Madrasah Tsanawiyah context, and carry the analysis through to effectiveness testing, as understanding the impact of a learning tool on student outcomes is crucial in education.

Based on the above explanation, this study contributes to the development of a product in the form of a feasible, effective, and digital literacy-based learning module as a novel output. Additionally, measuring student learning outcomes through effectiveness testing represents an innovation in the process, which will add to the literature on the implementation of digital literacy-based learning modules after they have been applied to students..

Research Method

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This type of research is research and development with a 2x3 factorial experimental design, where researchers will develop a product in the form of a digital literacy-based learning e-module to improve informatics learning outcomes at MTsN 3 Langkat.

The population in this study consisted of all eighth-grade students at MTsN 3 Langkat, totaling 313 students. From the entire eighth-grade population, a sample was selected using the Cluster Random Sampling method, resulting in two experimental classes: Class VIII-8 with 30 students as Experimental Class One, and Class VIII-4 with 30 students as Experimental Class Two. The subjects involved in the trial of this digital literacy-based instructional module development included eighth-grade students at MTsN 3 Langkat, an Informatics lecturer as the content expert, and Educational Technology lecturers as the instructional design expert and media expert.

Research and development is a process or method used to validate and develop a product. It is conducted by following procedures that serve as guidelines in the research activities. These procedures involve activities to develop and test the effectiveness of the product before it is finalized and disseminated. The procedures or stages are determined according to the development model used in the research.

In this study, the development model applied is the ASSURE model. The ASSURE model is one of the models that can be used to develop educational products to support student learning, such as teaching materials or media, methods, and instructional strategies. The ASSURE model consists of six stages: (1) Analyze learner characteristics, (2) State performance objectives, (3) Select methods, media, and materials, (4) Utilize media and materials, (5) Require learner participation, (6) Evaluate and revise (Heinich, 2002).

The product was tested by involving students of MTsN 3 Langkat, the treatment stage in experimental group one and experiment two had a design that can be seen in Table 1 as follows.

Table 1. 2x3 Factorial Experimental Research Design

Learning Style (B) / **Module (A)**	**VISUAL (B1)**	**AUDITORY (B2)**	**KINESTHETIC (B3)**
EMPBLD (A1)	**A1B1**	**A1B2**	**A1B3**
MK (A2)	**A2B1**	**A2B2**	**A2B3**

At the stage of treatment of the effectiveness of digital literacy-based learning modules, this study divided the research group into two, namely experimental group 1 which was given a digital literacy-based learning module and experimental group 2 which was given a conventional module. This study used a 2x3 factorial design with independent variables, namely Digital Literacy-Based Learning E-Module and Conventional Module (MK), dependent variables, namely learning outcomes and moderator variables, namely learning styles (visual, auditory and kinesthetic).

Result and Discussion (12pt, Times New Roman)

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Feasibility Results

The product developed in this study is a Digital Literacy-Based E-Module, aimed at improving student learning outcomes. The development stages of the product follow the ASSURE model, which includes: (1) Analyze Learner Characteristics, (2) State Performance Objectives, (3) Select Methods, Media, and Materials, (4) Utilize Media and Materials, (5) Require Learner Participation, and (6) Evaluate and Revise.

The ASSURE development model is one of the models that can be used to develop educational products in support of student learning (Heinich, 2002). In this study, the Rowntree development model is integrated into the third stage—Select Methods, Media, and Materials—to help design and develop the teaching materials or learning modules. The planning and development of the Digital Literacy-Based E-Module using the Rowntree model involves three main stages: the first stage is planning, the second is preparation for writing, and the third is writing and editing (Nur et al., 2024).

The Analyze Learner Characteristics and State Performance Objectives stages involve identifying problems and needs through interviews, observations, and documentation to determine the learning objectives. The Select Methods, Media, and Materials stage, which is integrated with the Rowntree model, focuses on designing the e-module by collecting materials, planning the module structure, preparing to write, writing, and editing, which results in a draft or prototype.

The Utilize Media and Materials and Require Learner Participation stages involve development and implementation. At this stage, product validation is carried out through a series of trials and revisions, ensuring that the Digital Literacy-Based E-Module is valid. The trials include 1) Content expert validation, 2) Instructional design expert validation, and 3) Media expert validation. The implementation phase includes 1) Individual testing, 2) Small group testing, and 3) Large group/field testing.

The final stage, Evaluate and Revise, is conducted to gather feedback from the implementation results in order to assess the feasibility and practicality of the product.

The developed product has been evaluated by material expert validators, namely Dr. Hermawan Syahputra, S.Si., M.Si and Fahmy Syahputra, S.Kom., M.Kom. The developed product has been evaluated by the validator of learning design experts, namely Prof. Dr. Abdul Hamid K, M.Pd and Prof. Dr. Samsidar Tanjung, M.Pd. The evaluation result data can be seen in Table 3 as follows. The developed product has been evaluated by media expert validators, namely Dr. Agus Junaidi, S.T., M.T. and Dr. Eng. Mansur AS, S.Kom., M.T.

The individual trial was conducted on three students from MTsN 3 Langkat who were not part of the research sample. The purpose of this individual trial was to identify shortcomings in the developed learning module and to assess the quality of its development before proceeding to the small group trial. The small group trial involved nine students from MTsN 3 Langkat who were also not part of the research sample. The objective of this trial was to further identify any deficiencies in the learning module and evaluate its quality prior to the large group trial. The large group trial was carried out with thirty-two students from MTsN 3 Langkat who were not included in the research sample. The aim of this trial was to assess potential weaknesses and the overall quality of the developed learning module before it was implemented in the experimental class.

Based on the results of the questionnaire, data was obtained that the results of the Digital Literacy-Based Learning E-Module feasibility assessment from the validator material experts, learning design experts, media experts, individual tests, small group tests and large group tests had an average value with data details as seen in Table 2 below.

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Tabel 2. Feasibility Test Results

Validators	1	2	Average
Ahli Materi	86,6%	85,71%	86,15%
Learning Design Expert	89,05%	90%	89,52%
Media Expert	89,56 %	91,30%	90,43%
Individual Test	83,56%		83,56%
Small Group Test	90,18%		90,18%
Large Group Test	89,8%		89,8%
Average			88,27%

Practical Results

The practicality test was conducted with thirty-two students from MTsN 3 Langkat who were not included in the research sample. The purpose of this practicality test was to evaluate the ease of use and efficiency of the learning module from the students' perspective. The practicality test was also carried out by the teacher who implemented the learning module during the teaching process. The aim of this test was to assess the ease of use and efficiency of the module from the teacher's perspective.

Based on the results of the questionnaire, the data showed that the average practicality scores of the Digital Literacy-Based E-Learning Module, as assessed by both students and the teacher, are presented in detail in Table 3 below.

Table 3. Practicality Test Result

Assessor	Percentage
Student	89,4%
Teacher	84,15%
Average	86,77%

Effectiveness Results

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The effectiveness of the digital literacy-based e-module compared to the conventional module can be analyzed and interpreted by examining the students' learning outcome data, including the highest score (X_{max}), lowest score (X_{min}), and average score ($\overline{X}$) for both Experimental Class One and Experimental Class Two, as shown in Table 5 below.

Table 5. Learning Outcomes of Experimental Class 1 and Experimental Class 2

Class	Learning Outcome Value			
	X_{min}	X_{max}	$\overline{X}$	SD
Eksperiment 1	70	92	79,97	6,75
Eksperiment 2	61	82	73,60	5,07

Two-way ANOVA analysis results

To determine the differences in learning outcomes based on the type of module, learning styles, and the interaction between module type and learning style, a two-way ANOVA test was used. The results are presented in the following Table 6.

Table 6. Two-Way Analysis of Variance Results

SOURCE OF VARIANCE	JK	Db	RJK	F count	F table
Between A (Module)	608,017	1	608,016	34,917	3.17
Between B (Learning Style)	994,433	2	497,216	28,554	3.17
AB Interaction	133,433	2	66,716	3,8314	3.17
Within-group	940,3	54	17,412		
Total	2676,183	59			

From the table, it can be seen that the difference between learning modules shows an $F_{calculated}$ value (F_h) which is compared to the F_{table} value at a significance level of 5% (0,05; 2; 54), which is 3,17. Since $F_h > F_{table}$ (34,92 > 3,17), it can be concluded that there is a significant difference in informatics learning outcomes between the Digital Literacy-Based E-Module and the Conventional Module. Therefore, the null hypothesis H_0 is rejected and the alternative hypothesis H_a is accepted.

Similarly, the difference in learning styles shows an F_h value that exceeds the F_{table} value at the 5% significance level (0.05; 2; 54), which is 3,17. Since $F_h > F_{table}$ (28,55 > 3,17), it can be concluded that there is a significant difference in informatics learning outcomes based on learning styles. Therefore, the null hypothesis H_{05} is rejected and the alternative hypothesis H_a is accepted.

The interaction between learning modules and learning styles also shows a significant difference, as the F_h value exceeds the F_{table} value at the same significance level (0.05; 2; 54 =

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3.17). Since $F_h > F_{table}$ (3,83 > 3,17), it indicates a significant interaction effect between the type of learning module and students' learning styles on informatics learning outcomes. Therefore, the null hypothesis H_0 is rejected and the alternative hypothesis H_a is accepted.

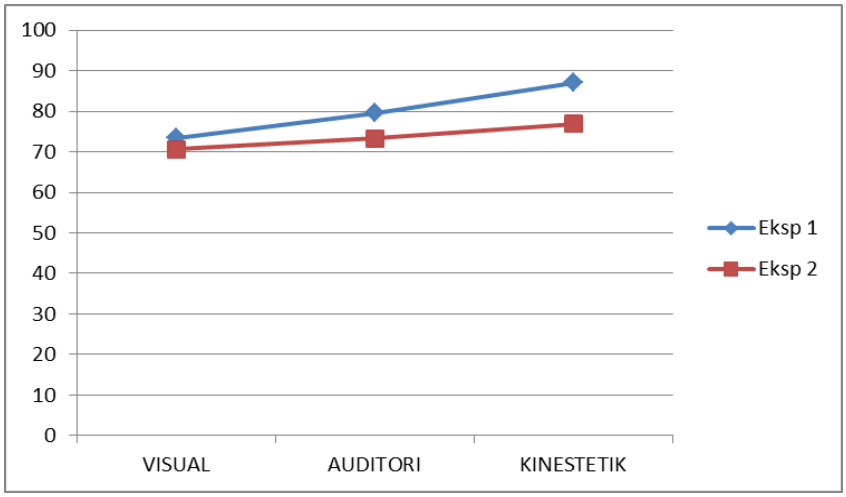

Figure 1. Interaction Between Learning Modules And Learning Styles

Because there is interaction, further testing was carried out, namely the Tuckey test, with the following results:

The results of informatics learning in Experimental Class 1 and Experimental Class 2, when consulted with the Tukey table for df (6,60) = 4,16, show that Qcalculated > Qtable (11,82 > 4,16). This means that there is a significant difference between the informatics learning outcomes in Experimental Class 1 and Experimental Class 2.

The results of informatics learning in Experimental Class 1 with visual learning style and in Experimental Class 2 with visual learning style, when consulted with the Tukey table for df (6,60) = 4,16, show that Qcalculated > Qtable (5,19 > 4,16). This indicates that there is a significant difference between the informatics learning outcomes in Experimental Class 1 with visual learning style and Experimental Class 2 with visual learning style.

The results of informatics learning in Experimental Class 1 with auditory learning style and in Experimental Class 2 with auditory learning style, when consulted with the Tukey table for df (6,60) = 4.16, show that Qcalculated > Qtable (11,50 > 4,16). This means that there is a significant difference between the informatics learning outcomes in Experimental Class 1 class with auditory learning style and Experimental Class 2 with auditory learning style.

The results of informatics learning in Experimental Class 1 with kinesthetic learning style and in Experimental Class 2 with kinesthetic learning style, when consulted with the Tukey table for df (6,60) = 4,16, show that Qcalculated > Qtable (18,74 > 4,16). This indicates that there is a significant difference between the informatics learning outcomes in Experimental Class 1 with kinesthetic learning style and Experimental Class 2 with kinesthetic learning style.

The results of informatics learning in Experimental Class 1 with visual learning style and auditory learning style, when consulted with the Tukey table for df (6,60) = 4,16, show that Qcalculated < Qtable (-11.32 < 4.16). This means that there is no significant difference

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between the informatics learning outcomes in Experimental Class 1 with visual learning style and those with auditory learning style.

The results of informatics learning in Experimental Class 1 with visual learning style and kinesthetic learning style, when consulted with the Tukey table for df (6,60) = 4.16, show that Qcalculated < Qtable (-25.24 < 4.16). This means that there is no significant difference between the informatics learning outcomes in Experimental Class 1 with visual learning style and those with kinesthetic learning style.

The results of informatics learning in Experimental Class 1 with auditory learning style and kinesthetic learning style, when consulted with the Tukey table for df (6,60) = 4.16, show that Qcalculated < Qtable (-13.92 < 4.16). This means that there is no significant difference between the informatics learning outcomes in Experimental Class 1 with auditory learning style and those with kinesthetic learning style.

The results of informatics learning in Experimental Class 2 with visual learning style and auditory learning style, when consulted with the Tukey table for df (6,60) = 4.16, show that Qcalculated < Qtable (-5.01 < 4.16). This indicates that there is no significant difference between the informatics learning outcomes in Experimental Class 2 with visual learning style and those with auditory learning style.

The results of informatics learning in Experimental Class 2 with visual learning style and kinesthetic learning style, when consulted with the Tukey table for df (6,60) = 4.16, show that Qcalculated < Qtable (-11.69 < 4.16). This means that there is no significant difference between the informatics learning outcomes in Experimental Class 2 with visual learning style and those with kinesthetic learning style.

The results of informatics learning in Experimental Class 2 with auditory learning style and kinesthetic learning style, when consulted with the Tukey table for df (6,60) = 4.16, show that Qcalculated < Qtable (-6.68 < 4.16). This indicates that there is no significant difference between the informatics learning outcomes in Experimental Class 2 with auditory learning style and those with kinesthetic learning style.

Conclusion

Based on the results obtained from the data analysis, the conclusions of this study are as follows: (1) the digital literacy-based e-module developed for the Informatics subject at MTsN 3 Langkat is considered highly valid and its accuracy has been tested, (2) the digital literacy-based e-module developed for the Informatics subject at MTsN 3 Langkat is considered highly practical and its accuracy has been tested, (3) the learning outcomes of students who used the digital literacy-based e-module are higher than those who used conventional modules, and this has been tested and proven, (4) there is a significant difference in student learning outcomes between those who used the digital literacy-based e-learning module and those who used conventional modules, as shown by two-way ANOVA analysis, and this has been tested and proven, (5) there is a significant difference in student learning outcomes based on learning styles—visual, auditory, and kinesthetic—as shown by two-way ANOVA analysis, and this has been tested and proven, (6) there is an interaction between the digital literacy-based e-learning module and learning styles in influencing student learning outcomes, as shown by two-way ANOVA analysis, and this has been tested and proven.

Recommendation

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Recommendations for future research include conducting similar studies using different subject materials or grade levels so that the results can contribute to the advancement of education. Furthermore, innovation in developing digital literacy-based learning modules in other subjects is encouraged to enhance student learning outcomes. Challenges or issues that may have affected the results of this study include the time required to determine students' learning styles, unexpected damage to computers in the laboratory, and unstable internet connectivity.

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