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Deep Learning-Based E-Module and Motivation Levels to Enhance Students' HOTS-based Science Literacy

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Abstract

The goals of this study were to determine: 1) feasibility and practicality of deep learning-based electronic module, and 2) effectiveness of the deep learning-based electronic module and the role of motivation levels in enhancing students' HOTS-based Science Literacy ability. Type of this study is Research and Development (R&D) and use the ADDIE development model. The study involved 42 students from SMA Negeri 16 Medan as the research sample. Two-Way ANOVA was used for hypothesis testing. The yields of feasibility and practicality test indicate that the deep learning-based electronic module is feasible and practical as teaching material. Feasibility were assessted by matter and media experts. Score for matter feasibility was 3.55 (categorized as very good) and for media feasibility was 3.79 (categorized as very good). Practicality assessments were based on student and teacher responses; the scores obtained were 84.27% (very good) for teachers and 75.27% (good) for students from the experimental class. The N-gain score for the experimental class was 0.75, while the N-gain score for the control class was 0.24. Two-Way ANOVA results show a significant difference in HOTS-based Science Literacy ability, with the experimental class outperforming the control class (Sig <.001). Significant differences were also observed in HOTS-based Science Literacy ability based on students' motivation levels (Sig.<.001). However, there was no interaction between teaching material and motivation levels (Sig.<.218). Instead of playing as a moderate variabel, motivation levels also play as independent variable that give direct effects (main effects) on the dependent variable.

Keywords: Deep Learning, Electronic module, HOTS-based science literacy, Motivation level, Inquiry-based learning

1. Introduction

Science literacy and higher order thinking skills (HOTS) are crucial for navigating the challenges of the 21st century. Science literacy includes four main parts, such as science context, science competency, science knowledge, and atitude towards science (OECD, 2018).

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Based on these four main parts, science literacy entails the ability to explain scientific phenomena, evaluate and design scientific inquiries, and interpret data while providing scientific substantiation (Tuttle et al., 2023). Higher-order thinking skills includes three abilities in taxonomy bloom, namely anlysis, evaluation, and creation (Rizki et al., 2024). Including three thinking abilities, High-order thinking skill enable individuals to think logically, critically, and creatively to devise appropriate solutions for problem-solving. These skills comprise a combination of analytical, evaluative, and creative abilities (Amin & Jaslin, 2021). The integration of higher-order thinking skills and science literacy can increase the capacity to conquer complex issues and generate effective solutions grounded in scientific inquiry and evidence. This combined capability can be termed HOTS-based science literacy.

Unfortunately, the science literacy and HOTS of students in Indonesia remain low, as evidenced by the country's PISA scores and rankings. Since first participating in PISA in 2000, Indonesia has consistently ranked at the bottom. Results from the 2022 PISA assessment placed Indonesia on 67th position of 81 countries, with a decresing of 12-point in its score. Science literacy is one of the aspects assessed in PISA. But it was set to be reclassified as "scientific competence" starting in 2025. Several factors contribute to this low level of science literacy among students: a lack of mastery regarding basic scientific concepts, science instruction that remains teacher-centered rather than student-centered, an inability to interpret tables or graphs, and a lack of student interest in reviewing the material (Yusmar & Fadilah, 2023).

The Indonesian government has taken concrete action to address this issue through the implementation of the Kurikulum Merdeka integrated with a deep learning approach. Deep learning is an approach that emphasizes the integration of theory and practice to foster an adaptive mindset and creative solutions (Suyanto et al., 2025). This approach encompasses three key aspects such as mindful learning, meaningful learning, and joyful learning. Mindful learning focuses on mastering fundamental concepts. meaningful learning emphasizes deep understanding by connecting basic concepts and knowledge to form new concepts. Joyful learning prioritizes an enjoyable educational experience by creating a learning atmosphere that is positive, fun, challenging, and motivating (Kemendikbud, 2025).

Deep learning approaches encompass various instructional models, inquiry learning model is one of them. The inquiry learning is a discovery-based model that guides students to discover new concepts (Qablan et al., 2024; Baharudin et al., 2024). Generally, inquiry models are categorized into two types: open inquiry and guided inquiry. The guided inquiry model is particularly suitable for secondary school students because the teacher assists in guiding them toward discovering new concepts and knowledge—especially through experimentation. Syntax of this learning model are orientation, problem formulation, hypothesis generation, data collection, hypothesis testing, and drawing conclusions. During the hypothesis generation stage, students hone their critical, logical, and creative thinking skills by formulating tentative answers to the problems identified in the problem formulation stage. Consequently, the inquiry model is highly effective for fostering students' science literacy and Higher-Order Thinking Skills (HOTS), provided that each stage is appropriately designed. Previous research indicates that inquiry models can enhance HOTS (Abdurrahman et al., 2021), improve scientific

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understanding (Safkolam et al., 2024), and boost critical thinking skills (Sutiani et al., 2021; Sapriati et al., 2024). Guided inquiry models have successfully improved critical thinking skills (Ali et al., 2023) and creative thinking skills (Santosa & Ratih, 2024), as well as science process skills (Juniar et al., 2021).

Although, guided inquiry was proven to enhance students' thinking ability, implementation of this learning model still face several challenges, such as consume more time (Laili et al., 2023), teacher should masters the knowledge well, and success of its implementation is dependent on other factors, like students' basic consept mastery and learnig motivation (Purwasi, 2020). The weakness of the guided inquiry will be completed through this research. This learning model can be implementated through teaching materials, so it can take more little time and students can repeat what they have studied before. Blending guided inquiry learning with deep laerning approach will make learning process be meaningful. As explained previously, deep learning consists of three main parts, namely mindful, meaningful and joyful. So, this teaching materials will consists of three parts, mindful for mastery basic concept, meaningful for finding new concept and knowledge by exploring relevan information from many sources, and joyful for completing every question and exercise seriously but happily too. By deep learning-based teaching materials, guided inquiry is used not only for learning basic consept but for exploring and finding new concept.

An electronic module (electronic module) is a digital teaching material that can be accessed anytime and anywhere by gadget (Purba et al., 2022). A key advantage of using electronic modules is that students can manage their own study pace and approach to the material based on their individual understanding and capabilities (Ruhiyat, 2009). Utilizing electronic modules can also boost student motivation, as these digital materials are designed to be engaging through the incorporation of various multimedia features (Wagner, 2008). So, product of this research is Deep Learning-based electronic module.

Furthermore, this research also exam role of motivation in learning. Theoretically, motivation plays a crucial role in the learning process. Motivation influences how learners participate in learning activities (Umar et al., 2023). Learning motivation drives individuals to exert effort toward improving their learning outcomes (Tutupary et al., 2024). Based on the Instructional Materials Motivation Survey (IMSS), there are four aspects are measured, namely: attention, relevance, confidence, and satisfaction (Huang & Hew, 2016). Deep Learning-based electronic module presents chemical kinetics as subject matter. Interviews with chemistry teachers indicate that chemical kinetics is a topic students find difficult to grasp. Yet, this topic is encountered at both the secondary school and university levels—specifically when students pursue majors related to chemistry. Based on the preceding explanation, the objectives of this study are to examine: 1) feasibility of a deep learning-based electronic module, 2) practicality of deep learning-based electronic module, 3) HOTS-based science literacy ability of students in the experimental and control classes, 4) HOTS-based science literacy ability of students across high, medium, and low levels of motivation, 5) interaction between teaching materials and motivation levels in influencing students' HOTS-based science literacy ability.

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2. Methods

2.1 Types of Research

The type of this study was the Research and Development (R&D) and used the ADDIE development model. The ADDIE model has five stages: Analysis, Design, Development, Implementation, and Evaluation (Sugihartini & Yudiana, 2018).

2.1.1 Analysis

At the analysis stage, researcher collected required information for developing the teaching materials. Researcher used student and teacher's questionnaire, made analysis of chemistry textbooks, and conducted interview to the teachers.

2.1.2 Design

At the design stage, researcher made design of Deep Learning-based electronic module based on results of analysis stage. Researcher planned about content, presentation, language, and graphical.

2.1.3 Development

At the development stage, researcher produces the completely Deep Learning-based electronic module and examined feasibility of the product. Feasibility assesment were executed by subject matter expert dan media expert. The experts consist of two lecturers, one for subject matter expert and another one for media expert.

2.1.4 Implementation

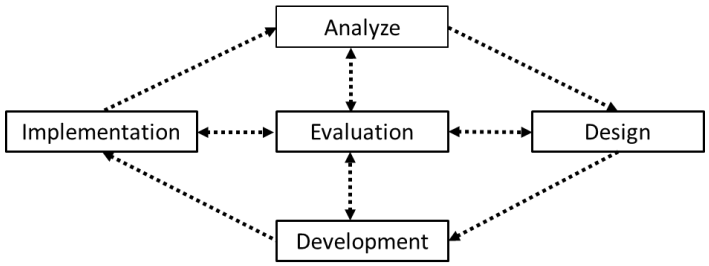
At the implementation stage, deep learning-based electronic module were used by students as their teaching materials. At this stage, researcher also collected data such as results of HOTS-based science literacy test, motivation levels test and results of practicality test.

2.1.5 Evaluation

At the evaluation stage, researcher evaluated entire process, started from the analysis to the implementation stage. At this stage, researcher also conducted statistical analysis for answering the hypothesis in this study.

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Figure 1.
ADDIE Develeopment Model



(Slamet, 2022)

2.2. Population and Sample

The population of this study consisted of Grade XI IPA students at SMAN 16 Medan. Participants in this research was chosen by purposive sampling technique. This sampling technique using existing classes (Imansari & Kholifah, 2023), namely experimental class and control class. Total participants were 42 students. SMAN 16 Medan utilized chemistry textbook as their teaching materials and implementated the Kurikulum Merdeka. Before applied to experimental class, Deep Learning-based electronic module was used by 31 students in trial class.

2.3 Research Instruments

Instruments used in this research were a BSNP validation sheet to measure the feasibility of the deep learning-based electronic module; student and teacher response questionnaires to evaluate the electronic module's practicality; a motivation questionnaire to measure motivation levels; and twenty multiple-choice questions to measure students' HOTS-based science literacy. The BSNP sheet and response questionnaires utilized the following assessment categories:

Table 1.
Categories Of Feasibility and Practicality

Value Range	Percentage (%)	Categories
1.00 – 1.74	25.00 – 43.5	Poor
1.75 – 2.49	43.75 – 62.25	Fair
2.50 – 3.24	62.5 – 81.00	Good
3.25 – 4.00	81.25 – 100	Very Good

(Chan & Barlis, 2023)

2.4 Data Analysis Techniques

Data analysis is the process of converting data into easily understandable information (Sarker, 2021). Beyond making data more comprehensible, data analysis techniques are used to express population characteristics and draw conclusions regarding hypotheses under investigation. The specific method employed here is inductive analysis. This technique is utilized when a

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researcher aims to draw conclusions about a phenomenon involving variables within a population (Pasaribu et al., 2022).

2.4.1 N-gain Test

The N-gain test is conducted to determine the improvement in students' abilities following a specific treatment (Isnaniah & Imamuddin, 2020). In this study, the treatment refers to the use of different instructional materials. The formula for calculating the N-gain score is as follows:

$$N_{gain} = \frac{Posttest\ Score - Pretest\ Score}{Max\ Score - Pretest\ Score} \quad \text{(Eq. 1)}$$

The N-gain score categories are as follows:

Tabel 2.
Categories of N-gain Test Result

N-gain Score	Categories
$g \geq 0.7$	High
$0.3 < g < 0.7$	Medium
$g \leq 0.3$	Low

2.4.2 Normality and Homogenity Test

Normality test is conducted to ensure that the data to be tested are normally distributed. This study used Shapiro-Wilk test for testing normality. Shapiro-Wilk test is used in this study because the sample size is less than 50. Data are considered normally distributed if the Sig. value is ≥ 0.05 (Rusyana & Adirestuty, 2024). Homogeneity test is a testing to ensure that two or several groups originate from equal variances population. Homogeneous data indicate that the samples being tested come from the same variance. Data are considered homogeneous if the Sig. value is ≥ 0.05 (Calle-saldarriaga et al., 2021).

2.4.3 Hyphotesis Test

Hypothesis testing for this study employed two-way ANOVA using SPSS 31 for Windows. Two-way ANOVA is utilized when a study involves more than two variables, with one of the independent variables comprising three or more groups (Sugiyono, 2025). The testing criteria dictate that if the Sig. value is ≤ 0.05, there are differences in HOTS-based science literacy ability depending on the teaching materials and motivation levels, and an interaction between teaching materials and motivation levels in influencing these abilities.

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3. Result and Discussion

3.1 Result

3.1.1 Feasibility Test Result

The feasibility test results for the deep learning-based electronic module are presented in Table 3.

Table 3.
Feasiblity Test Result of Deep Learning based electronic module

Feasibility Aspect	Indicators	Value	Average Value	Categories
Material	Content	3.52	3.55	Very Good
	Presentation	3.58		
Media	Language	3.93	3.79	Very Good
	Graphics	3.64		

Table 3 shows the feasibility test results from the subject matter expert and media expert. The material feasibility test score was 3.55, placing it in the very good category. This score was the average of the content feasibility and presentation feasibility. The scores for content feasibility and presentation feasibility were 3.52 and 3.58 respectively. Meanwhile, the media feasibility test score was 3,79, making it fell into very good category. Media feasibilty test consists of language and graphic design feasibilty. The details of the language feasibility score were 3,93 and the graphic design feasibility was 3,64.

3.1.2 Practicality Test Result

The Practicality test result for the deep learning-based electronic module is presented in table 4 and table 5. The practicality test results came from teachers and students' responses.

Table 4.
Teacher Responses Result

Indicator	Average Percentage	Categories
Material	98.21%	Very Good
Presentation	100%	Very Good
Language	91.67%	Very Good

Tabel 5.
Students Responses Result

Indicator	Average Percentage	Categories
Interest	78.63%	Good
Material	75.27%	Good
Language	78.76%	Good

Table 4 presents the results of teacher responses, while Table 5 presents the results of student responses. These responses were used to measure the practicality of the deep learning-based

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electronic module. The average teacher response percentages for the material, presentation, and language aspects in deep learning-based electronic module were 98.21%, 100%, and 91.67%, respectively, falling into the very good category. Averagewhile, the average student response percentages for the interest, material, and language aspects were 78.63%, 75.27%, and 78.76%, respectively, falling into the good category.

3.1.3 Validity and Reliabilty Instrument Test Result

Instrument tests forming multiple choice refering to assess HOTS-based science literacy students had to be examined. Goal of the examine was to know the instruments was valid and reliable. Validity test aimed to make sure that the instruments can measure the students' ability accurately. Meanwhile, reliability test aimed to gauged consistency of the instruments in measuring the students' ability. Out of the 40 instruments multiple choice tests, 20 of it was valid with r- calculation score was over 0.344. These valid instruments were reliable r_{11} was 0.92.

3.1.4 Hypothesis Test Result

Hypothesis test results can be obtained after performing normality and homogeneity tests on the N-gain data. N-gain data can be calculated once the pre-test and post-test data have been obtained.

Table 6.
Pre-Test and Post-Test Result

	Average	Max. Value	Min. Value	Std. Deviation
Eksperiment Pre-test	26.43	45.00	10.00	8.96
Control Pre-test	29.76	65.00	5.00	17.92
Eksperiment Post-test	81.43	95.00	65.00	8.68
Control Post-test	47.38	70.00	15.00	14.97

Table 6 show the results of pre-test and post-test score. The pre-test results indicate that, initially, the HOTS-based science literacy ability of students in the control class were higher than those of students in the experimental class, judging by the average and highest scores obtained. Experimental class's students got 26.43 as average of pre-test, with a highest score was 45.00, whereas average of -test score of students from the control class was 29.76, with a highest score was 65.00. However, after using different teaching materials, average and highest scores of the students from experimental class was higher than the students from the control class. Average of post-test score for the experimental class was 81.43, with a highest score was 95.00, while average of post-test score for the control class was 47.38, with a highest score was 70.00. Based on the obtained pre-test and post-test data, the N-gain values shown in Table 7 were calculated.

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Table 7.
N-gain Test Result

Class	Average N-gain	Average N-gain Percentage	Categories
Eksperiment	0.75	75.00%	High
Control	0.24	24.00%	Low

Based on Table 7, N-gain score of students from the experimental class was higher than students from the control class. N-gain score achived by students in the experimental class was 0.75, while students from the control class got 0.24 as N-gain score. Experimental class got high category for its N-gain score whereas control class got low category for its N-gain score.

Table 8.
Normality Test Result

Class	Shapiro-Wilk		
	Statistic	df	Sig.
Eksperiment	0.941	21	0.225
Control	0.924	21	0.107

Table 9.
Homogenity Test Result

	Levene Statistic	df1	df2	Sig.
Eksperiment Control	2.081	1	40	0.157

The normality test is presented in Table 8, and the homogeneity test is presented in Table 9. Sig. value of normality test is 0.225 and 0,107 for experimental class and control class respectively. This yield indicates that the data are normally distributed. The homogeneity test yielded a Sig. value of ≥ 0.05, indicating that the data are homogeneous. Therefore, two-way ANOVA test can be conducted.

Table 10.
Two-way ANOVA Test Result

Component	**Total Sum of Squares**	**Dh**	**Mean Square**	**F**	**Sig.**	**Partial Eta Squared**
Bahan_ajar	15175.533	1	15175.533	174.667	<.001	0.829
Tingkat_Motivasi	1612.409	2	1612.409	9.279	<.001	0.340
Bahan_ajar * Tingkat_Motivasi	275.862	2	275.862	1.588	.218	0.081

The results of the two-way ANOVA test were obtained to address the research hypotheses. The ANOVA test results are presented in Table 10. Difference is stated significant if Sig. value is ≤ 0.05. Table 10 shows a significant difference in students' HOTS-based science literacy ability based on the teaching materials used, as evidenced by a Sig. value of <.001. A significant

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difference in HOTS-based science literacy ability was also observed based on motivation levels (Sig. <.001).

Table 11
Description of 2x3 Factorial HOTS-based science literacy ability

Motivation Levels	Teaching Materials		Average
	Deep Learning-Based Electronic module	Chemistry Textbook	
Low	67.6667	15.7273	26.8571
Medium	69.1429	30.8571	50.0000
High	80.6364	39.6667	71.8571
Average	74.9524	24.1905	49.5714

Table 11 presents the details of the differences in students' scientific literacy HOTS based on teaching materials and motivation levels. However, there was no interaction between teaching materials and motivation levels (Sig. 0.081). Table 11 indicates that students with high motivation levels possess higher HOTS-based science literacy ability compared to students with moderate or low motivation levels.

3.2 Discussion

The deep learning-based electronic module is suitable for using as teaching material when evaluated in terms of content, presentation, language, and graphic design. This developed teaching material aligns with the learning outcomes (CP) of Kurikulum Merdeka. Aligning teaching materials with learning outcomes is crucial for ensuring that instructional planning is focused and relevant to the students who will use the materials; it is important to avoid having students study content that is inappropriate for their school level (Hakim et al., 2024). Language plays a important role in instructional materials because students have a greater opportunity to construct concepts independently when they understand the content through easily comprehensible language (Qizi, 2024). Content within deep learning-based electronic modules is presented using two approaches: deductive and inductive methods. The deductive method provides students with explanations of fundamental concepts, whereas the inductive method involves deeper exploration, requiring students to apply that knowledge to answer more complex questions—a process that sometimes leads to the independent discovery of new concepts (Sekhar & Murthy, 2024). In terms of graphic design—specifically regarding illustrations—the deep learning-based electronic module is considered suitable. Illustrations are visual media that can be seen with the naked eye. They may take the form of objects used to facilitate explanation, comprehension, or depiction, or serve as a component of the written content (Azlan & Sulaiman, 2020).

The deep learning-based electronic module is practical to use, despite differences in assessment categories between teachers and students. Discrepancies in assessment regarding content and language indicators arise from differences in knowledge and competence. “Law No. 14 of 2005

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(Article 10, Paragraph 1) stipulates that professional competence is one of the competencies a teacher must possess." "According to Government Regulation No. 74 of 2008, professional competence is defined as a teacher's ability to master the fields of science, technology, and/or arts and culture that they teach. The scope of professional competence encompasses broad and deep mastery of the subject matter—in accordance with content standards—as well as mastery of the scientific concepts, structures, or methods underlying that material." "According to Rahmat Hidayat (in Hidayat & Abdilah, 2019, p. 92), a learner is an individual possessing innate potential—both physical and psychological—that requires development; cultivating this potential necessitates education provided by an educator." The definitions of teachers and students outlined above help explain why teachers rated the deep learning-based electronic module more highly than students did. Teachers possess robust, in-depth knowledge of the subject matter and a keen understanding of classroom needs; they also tend to place greater value on the novelty or innovation of instructional materials. In contrast, students are individuals who are just beginning to learn the material in a school setting. Consequently, when starting a new chapter, students must adapt—cognitively, affectively, and psychomotorically—to effectively grasp the content. This difference in adaptation requirements accounts for the disparity in responses between students and teachers. Nevertheless, based on the scores obtained from both groups, the deep learning-based electronic module is considered practical as teaching material.

There are two learning components of deep learning based-electronic module, namely basic understanding and in-depth understanding. Basic understanding encompasses the fundamental concepts and chemical kinetics calculation formulas that students must recognize, study, and master. Mastery of these fundamental concepts helps learners to develop their higher order thinking skills (Ramdani et al., 2021). Upon mastering the basic concepts of chemical kinetics, students proceed to the in-depth understanding component. This component is designed around the syntax of inquiry-based learning. The activities within this inquiry-based approach encourage students to achieve a deeper level of understanding and practice their HOTS. This consistent with the results of Qamariyah et al. (2021), who stated that during inquiry-based learning, students engage in various activities—such as comprehending and identifying problems, drawing conclusions, and ultimately generating new concepts and knowledge—thereby exercising their HOTS.

Motivation levels also significantly influence HOTS-based science literacy ability. Student with high level motivation is more success than students with moderate and low level motivation (Bolsen & Palm, 2026). Several previous studies indicate that motivation acts as a moderator variable; this role is evidenced by an interaction between the independent variable and motivation. However, motivation can sometimes function as an independent variable when it exerts a direct influence on the dependent variable (Bandhu et al., 2024). In fact, a moderation effect is distinct from an interaction effect (Rahadi & Farid, 2021). According to Table 4.21, the Partial Eta Squared values for teaching materials and motivation levels are 0.829 and 0.340, respectively. These values indicate that both teaching materials and motivation levels have a substantial effect on HOTS-based science literacy ability, as the values exceed 0.14. Previous studies also indicate that the level of motivation—as a second independent variable—exerts a

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direct influence on the dependent variable. Research conducted by Bajenied (2026) demonstrates that both extrinsic and intrinsic motivation significantly affect students' average grades, yet neither shows a significant interaction with other independent variables. Similarly, a study by Niu & Wang (2025) illustrates how intrinsic and extrinsic motivation influence students' academic success, while finding no significant interaction with other independent variables such as gender, parenting style, the health status of students and parents, aspirations, and parental income.

4. Conclusion

Based on the results of feasibility and practicality tests, deep learning-based electronic module is feasible and practical as a teaching material in chemical kinetics. Data analysis indicates that students using deep learning-based electronic module demonstrated higher HOTS-based science literacy ability better than students using textbooks. Motivation levels also influenced students' HOTS-based science literacy ability; higher motivation levels corresponded to higher proficiency in these skills. The absence of an interaction between the teaching materials and motivation levels indicates that both factors exert a direct influence on the dependent variable.

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