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Production and Utilization of Moodle-Based e-Learning to Enhance Higher-Order Thinking Skills with the STEM Approach

Mida Ayu Restanti, Neni Hasnunidah*, Agus Suyatna, Abdurrahman
Master of Science Education Study Program, Universitas Lampung, Indonesia

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***Correspondence Address:**
neni.hasnunidah@fkip.unila.ac.id

Abstract: This study aimed to develop a Moodle-based e-learning platform with a valid, practical, and effective STEM approach to enhance Higher-Order Thinking Skills (HOTS). The research methodology employed for development purposes was the ADDIE model, consisting of five distinct phases: Analysis, Design, Development, Implementation, and Evaluation. The selection of research subjects for the field trial was conducted through cluster random sampling, wherein experimental and control classes were chosen. The experimental class utilized a Moodle-based e-learning solution for instructional purposes, while the control class adhered to traditional learning methods. Data were collected using validated questionnaires and written tests. The findings indicated that the Moodle-based e-learning products with a STEM approach are effective in enhancing students' higher-order thinking skills. This was evident from the average n-Gain gain falling in the "medium" category at 0.62 and an effect size also in the "medium" category at 0.43. Student responses to the Moodle-based e-learning were very positive. Based on the research findings, the researcher offers some recommendations. Teachers aiming to utilize this product could enhance its effectiveness by incorporating additional platforms into their learning activities and resources. Additionally, other researchers interested in advancing further studies can introduce problem-solving activities to stimulate higher-order thinking skills (HOTS) in everyday situations. In conclusion, the Moodle-based STEM e-learning product is effective in enhancing students' HOTS.

INTRODUCTION

21st-century education requires students to have 6C skills: Creative, Critical Thinking, Communicative, Collaborative, Computational thinking, and Compassion (Tang et al., 2020). The 6C skills are interconnected with HOTS (Zikri et al., 2020). Higher-order Thinking Skills (HOTS) are high-level thinking skills that students must have (Putranta & Dwandaru, 2021; Wardani et al., 2020; Shanti et al., 2022; Yusof et al., 2023). Higher-order Thinking Skills (HOTS) are important for students to think critically in solving difficult problems (Tsaparlis, 2020; Razak et al., 2021; Syafryadin et al., 2021).

Existing facts have shown that science learning is only a process of knowledge transmission. Knowledge is presented as indisputable knowledge and facts and transferred from teachers to students (Maulina, 2020). Apart from that, when learning, students still have difficulty interpreting questions in depth and cannot separate the important parts of the questions to be used as keys to solving questions. Hence, students are not yet

skilled in working on oriented questions. Higher-Order Thinking Skill (HOTS) (Prayoga et al., 2020). The results of trying and associating activities enable students to think at a higher level (higher-order thinking skills) to think metacognitively. However, based on the observations and analysis results, when the teacher gives students questions, the student's way of thinking tends to be the same as the examples the teacher gave. But when students are given questions slightly different from the examples, they will find it difficult. In such conditions, students are usually only required to accept something important and memorize it. With this way of thinking, students become slow, and students can only solve questions that are classified as low-level (Handayani & Syukur, 2021).

The results of the questionnaire, which was distributed to 45 teachers in Lampung Province in January 2022, showed that the science learning process did not lead to HOTS, such as the implementation of learning still using discussions and lectures, the learning carried out was not yet inspiring and multifaceted, the assessment did not contain a probing question. HOTS, as a transfer process in the learning context, aims to create meaningful learning, which focuses on the ability of students to apply what they have learned to new situations without the direction or guidance of lecturers or other people. Moreover, HOTS is also seen as a critical thinking process to form students who can think logically (reasonably), be reflective, and make decisions independently (Solehuddin et al., 2023).

In response to HOTS learning, educators must carry out learning innovations that direct students to develop HOTS (Salampessy & Suparman, 2019). HOTS is aimed at helping students become independent problem-solvers and decision-makers in the future (Kaur et al., 2020). Various factors influence the low quality of Higher-order Thinking Skills in students. The low level of higher-order thinking skills is caused by the learning model used by teachers that has not led to students' higher-order thinking skills (Rintayati et al., 2021). The teaching and learning process is still teacher-centered (Sofianora et al., 2023), so students are less active in learning. In addition, the evaluation questions of the student teaching and learning process have not led to students' Higher-order Thinking Skills (Fitri et al., 2018). Therefore, there is a need for resources that can stimulate HOTS. Resources to stimulate HOTS need to contain stimulus components for thinking in images, graphics, audio, video, and simulations (Suyatna & Viyanti, 2020).

One form of use of learning resources that can be innovated in learning that can stimulate HOTS is choosing an LMS (Learning Management System), which corresponds to the utilization of e-learning (Sohaya, 2019). Learning using LMS is a field that continues to develop (Li, 2020). Learning Management System (LMS) plays a role in developing, managing, and distributing digital resources for learning (Aljawarneh, 2020). E-learning helps students' learning process become more interesting and interactive without time limits (Suharyat et al., 2023; Lee et al., 2020; Nuryatin et al., 2022). Learning Management System (LMS) plays a role in developing, managing, and distributing digital resources for learning (Aljawarneh, 2020).

Developing HOTS through an LMS requires an appropriate learning approach. One is STEM (Science, Technology, Engineering and Mathematics). STEM is an approach where Science, Technology, Engineering, and Mathematics are integrated, focusing on the learning process of solving real-life problems (Devi, 2018). Several studies have shown the effectiveness of using STEM in e-learning: 1) Learning using LMS is a field that continues to develop (Li et al., 2020). 2) The learning process that integrates the

STEM approach based on a review of research results shows that this approach effectively increases students' HOTS (Rosidin et al., 2019). This approach is suitable for stimulating HOTS because students will get used to forming logical thinking. This approach makes learning more meaningful by systematically integrating knowledge, concepts, and skills to solve problems (Diansah et al., 2021). 3) The role of an LMS using STEM can increase student engagement, motivation, collaboration, performance, retention, and critical thinking (Araya & Collanqui, 2021). STEM-based e-learning has a very positive impact and effectively improves students' Higher-order Thinking Skills (HOTS). Furthermore, HOTS characteristics do not cause heterogeneity in the results of STEM-based e-learning research on students' Higher-order Thinking Skills. These findings suggest that educators should choose STEM-based e-learning as one of the learning models to improve students' Higher-order Thinking Skills in Indonesia. STEM-based e-learning helps students grow their digital literacy (Solehuddin et al., 2023).

Moodle is the most popular open-source LMS and has a high level of acceptance (Al et al., 2018). Research results indicate that Moodle-based online learning is valid for optimizing learning performance (Suyatna et al., 2021). STEM-based Moodle content is declared effective because it can foster performance skills (Solehuddin et al., 2023). This is in line with the results of a questionnaire distributed to 45 teachers in Lampung Province, which stated that 91.3% of teachers agreed that it would be a developed-learning-based model with a STEM approach. So far, learning has not used a STEM approach due to limited learning resources and time. Science teachers in Lampung Province, especially in learning, mostly use learning resources in books, so this is unsuitable for stimulating HOTS.

HOTS abilities in students are very important as a skill requirement that must be possessed in the era of Industrial Revolution 4.0. Therefore, one of these efforts is to provide learning resources to help students improve HOTS, namely developing Moodle-based e-learning. These learning resources use an approach that can stimulate HOTS, namely by using a STEM approach, so that the learning resources and learning approaches developed can increase students' HOTS.

METHOD

This research refers to the research and development design used to design a learning system, namely the ADDIE model. The ADDIE model research procedure consists of five stages: analysis, design, development, implementation, and evaluation (Weldami & Yogica, 2023). The development procedure can be seen in Figure 1.

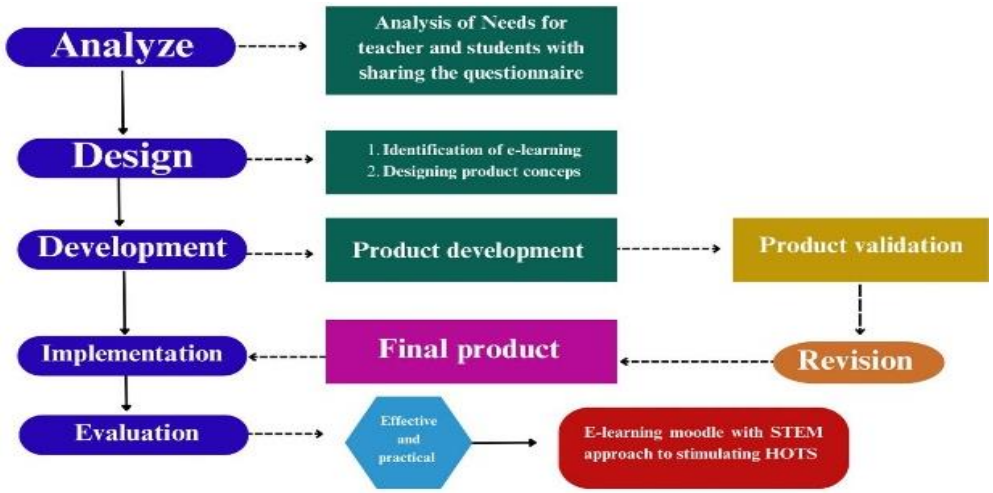

Figure 1. Design Procedure.

The Research Instrument

The analysis instrument was a questionnaire on product needs analysis using a Likert scale. The source of data for needs analysis is science educators in Lampung Province. The questionnaire for teachers and students includes questions about descriptions of science learning, learning resources, and the availability of E-learning adopted from research by Diansah and Asyhari (2020). The needs analysis questionnaire is presented in Table 1.

Table 1. Need Analysis Questionnaire.

Aspect	Indicator	Predictor
Learning at School	HOTS Oriented Learning	Application of active learning, which leads to the development of HOTS. The application of the learning carried out is challenging, thereby giving rise to critical thinking skills. The learning implementation carried out is inspiring and multifaceted (variations of C1-C6 thinking processes) to bring out positive habits in students, namely building character and developing Higher-order Thinking Skills (HOTs).
	HOTS Oriented Assessment	Application of question item analysis in assessing learning outcomes. The learning outcomes assessment contains tracking questions (probing questions) to encourage reasoning skills (critical, logical, and systematic thinking).
	Learning Resources	The use of Internet learning resources in learning. Need for learning resources. Opinions for developing learning resources.
	STEM Approach	Application of a STEM approach. Barriers to implementing a STEM approach.
E-Learning	Knowledge of E-learning	Application E-learning on learning. Obstacles in the implementation of E-learning.

Practicality will be measured using questionnaires and observation sheets. Data analysis from the questionnaire results will be presented in percentage form and then qualitatively interpreted. Observation sheets will be used to observe students' behavior and activities during the learning process. The observation results will be analyzed descriptively in a qualitative manner.

The effectiveness of E-learning will be measured using cognitive aspect tests for students. Relevant experts validated the test instruments used in the research. This test adapted to Bloom's Taxonomy on three aspects of the cognitive domain in high-level thinking abilities: analysis, evaluation, and creation. The examples of cognitive test questions that have been validated are presented in Table 2.

Table 2. Cognitive Test Question.

Learning Indicators	Question Indicator	Aspect	HOTS Indicator	Question
Building a solution that can be done by applying a mechanism to maintain the stability of human body temperature to a phenomenon in everyday life.	Presented with an animated video of a conversation between a breeder and a hen, students build a solution that can be implemented by applying a mechanism to maintain the stability of human body temperature in a phenomenon.	**C6**	Build, create	Please pay attention to the video!  After understanding the above problems, build the solution by solving

Learning Indicators	Question Indicator	Aspect	HOTS Indicator	Question
				problems that occur by applying the concepts of temperature, expansion, heat, and mechanisms for maintaining stable body temperature in animals!

Data Analysis

The cognitive test results were analyzed using N-Gain and Independent Sample T-Test. The impact of E-learning was assessed based on the N-gain scores of the experimental class and the variance in average N-gain scores between the experimental and control classes. Testing was conducted using the Independent Sample T-test. The test involved 7th-grade junior high school students in Tulang Bawang, Lampung Province. Purposive sampling was employed, involving two equally sized classes.

RESULT AND DISCUSSION

The first stage in carrying out research on the development of Moodle-based e-learning with a STEM approach is to conduct an analytical study. The results of the teacher needs analysis questionnaire regarding the development of Moodle-based e-learning with a STEM approach to enhance student HOTS are presented in Table 3.

Table 3. Results of Teacher's Need Analysis.

No	Statement Analysis	Percentage
1.	Teachers have carried out active learning, which led to the development of HOTS.	73.9
2.	Teachers carry out challenging learning so that critical thinking skills emerge.	82.6
3.	Teachers carry out learning that is inspirational and multifaceted (variations of C1-C6 thinking processes) to bring out positive habits in students, namely building character and developing Higher-order Thinking Skills (HOTs).	67.4
4.	The teacher in the learning assessment has carried out an analysis of the question items.	65.2
5.	The teacher has prepared a learning outcomes assessment that includes probing questions to encourage reasoning skills (critical, logical, and systematic thinking).	52.2
7.	Teachers have/frequently used the internet as a learning resource during science lessons, especially on calor topics.	78.3
8.	The teacher stated that the current learning resources for the calor topics were sufficient.	43.5
9.	The teacher stated that it was necessary to develop learning resources that could support science learning.	91.3
10.	Teachers in learning have/often used a STEM approach.	43.5
11.	Teachers stated that there were obstacles if/when implementing a STEM approach.	78.3
12.	Teachers have implemented e-learning in the classroom.	50.0
13.	The teacher believes that if e-learning is implemented in the classroom, there will be obstacles.	69.6
14.	Teachers agree if Moodle-based e-learning is developed in science learning.	91.3

The teacher needs analysis results show that most science teachers have carried out active, initiative, multifaceted, and challenging learning that led to the development of HOTS. However, the assessment of learning outcomes, which should coincide with HOTS-based learning and contain probing questions to encourage reasoning skills (critical, logical, and systematic thinking), has not been fully implemented. This is because the teacher has not fully analyzed the question items. Most teachers also stated that there had been a decline in learning

due to the pandemic, which a decline in student grades could prove. Furthermore, the needs analysis of learning resources results show that it is necessary to develop learning resources that can support science learning due to the lack of available learning resources. Some teachers have used e-learning as a learning resource in classroom learning. Other results related to the needs analysis regarding learning approaches state that most teachers have not used the STEM approach in learning due to obstacles, one of which is that the allocation of learning time using the STEM approach tends to be long. Based on this, the teacher stated that developing Moodle-based e-learning with a STEM approach was necessary.

E-learning products are designed following the indicators and learning objectives developed. The design contains content and learning activities that are based on the STEM approach and can enhance HOTS. The product concept design that has been carried out is designing the points made in e-learning. The concept of the product made can be seen in Figure 2.

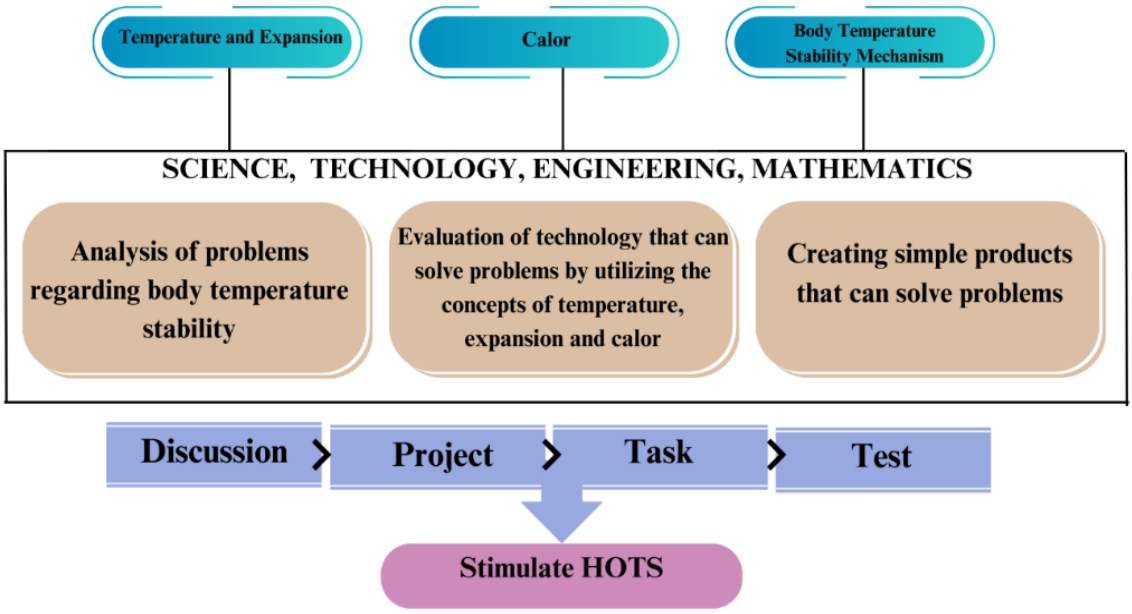

Figure 2. E-Learning Design.

This development research results in an e-learning product based on Moodle with a STEM approach aimed at stimulating Higher-Order Thinking Skills (HOTS). This product comprises learning management, activities, and resources. In this e-learning system, the learning management section includes a homepage containing information about the school's profile and a collection of school activity photos. Additionally, there is a login menu that both students and teachers use. Students and teachers can log in using the usernames and passwords provided by the administrator.

Furthermore, there is a "my course" menu that both students and teachers use to access the classes that have been provided. These classes have various learning activities, including discussions, virtual laboratories, assessments, attendance tracking, quizzes, and group projects, as well as resources such as e-modules, e-worksheets, videos, and animations. The learning activities and resources available in Moodle-based e-learning are presented interactively. The results of the development of Moodle-based e-learning are presented in Figure 3.

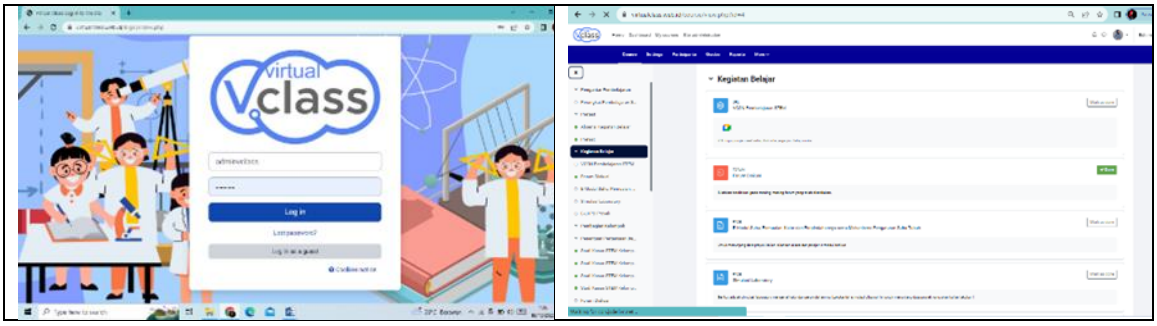

Figure 3. Moodle-based E-learning.

Figure 4. Interactive Learning on Moodle-based E-learning.

This suitability is based on the alignment of content and media, encompassing all components from e-learning, lesson plans, e-worksheets, and HOTS assessments, including a series of STEM learning activities. The learning planning, with the implementation of various learning strategies, greatly aids students in empowering and honing their thinking skills (Jaya et al., 2014).

The learning activities within Moodle-based e-learning include discussions, virtual laboratories, assessments, attendance tracking, quizzes, and group projects. The content available in e-learning includes e-modules, e-worksheets, videos, and animations. E-modules and e-worksheets are presented interactively as learning materials for students, and videos and animations are provided to make the

learning process interactive. Interactive learning enables students to learn independently and enjoy learning more (Herwiana & Laili, 2022). Discussion forums contain problems designed to cultivate students' high-level thinking skills, especially problem-solving abilities. Based on research conducted by Zainudin et al. (2021), it is demonstrated that students who participate and provide answers in online discussions during problem-solving activities have a better understanding of the concepts.

In this e-learning context, quizzes are included to assess students' Higher-order Thinking Skills (HOTS). Quizzes can enhance students' problem-solving abilities (Zainudin et al., 2021). The examples of interactive learning on Moodle-based e-learning are presented in Figure 4.

Field trials were conducted using a quasi-experimental research design, namely a nonequivalent control group design. The implementation was a field trial carried out in class VII A of SMP Negeri 2 Menggala Timur as an experimental class with 24 students. The research process begins with an introduction and a pretest to measure students' HOTS abilities. At the end of the lesson, a posttest is given to determine the increasing student HOTS. Learning in the experimental class is carried out experimentally blended learning.

Learning using Moodle-based e-learning with a STEM approach begins by listening to a problem case regarding the mechanism of body temperature stability in humans and animals. Next, in groups, students formulate scientific questions and discuss the answers. Questions and answers are written in discussion forums and e-worksheets. Discussions were carried out in person synchronously using e-learning. There is a learning disability e-learning via LMS-based Moodle in developing students' HOTS, namely a lack of interaction between teachers and students or even between students and sometimes more focused on technological aspects than educational aspects.

The next lesson is that students design a product plan. Students create product planning designs by writing down information related to the impacts that could arise if problems in the case of body temperature stability mechanisms are not resolved. Apart from that, students also write information about technology products that have been made by other people, tools, materials, and their functions and identify the advantages and disadvantages of technology products that other people have made. This implementation contains aspects of science.

Students then design the product they plan to create a process flow chart using the Canva platform and then upload it to the menu assignment of learning. Next, students prepare a product manufacturing planning schedule on the e-worksheet that has been provided. This implementation contains aspects of Technology because learning uses technology.

Students prepare the next product. This implementation contains aspects of Engineering. Project progress is written down by students on an e-worksheet to be monitored by the teacher. The teacher's role is to provide suggestions for improvement if students experience problems during product preparation through the discussion forum provided on e-learning.

During the product preparation process, students are asked to document it in video form and then upload it to the platform YouTube. Next, students conduct product testing by writing down the results of observations on the e-worksheet in graph/table form. This activity implements aspects of Mathematics. Also, in the e-worksheet, students are asked to discuss and fill in

their completed project reporting worksheet.

Learning designed with the STEM approach can train students' Higher-order Thinking Skills (HOTS) (Rosidin et al., 2019). STEM-based learning is expected to enhance high-level thinking abilities (HOTS) by fostering communication through discussions and mathematical activities. This can be a foundation for developing students' HOTS abilities and understanding (Solehuddin et al., 2023). One of the learning models that, in its process, allows learners to develop, analyze, and evaluate technology from the integrated perspective of science, engineering, and mathematics in a single learning process is STEM education (Busyairi et al., 2022).

The development product is also deemed effective, as seen through the improvement in students' Higher-order Thinking Skills (HOTS) scores, evident in the increased posttest scores after using the development product, which had a higher average compared to the pretest scores before using the learning program in the experimental class. After conducting the pretest and posttest score calculations, the next step involved calculating the N-Gain using SPSS 26 to determine the extent of improvement in Higher-Order Thinking Skills (HOTS) in both the experimental and control classes. The N-Gain values for the experimental and control classes are presented in Table 4.

Table 4. N-Gain Experiment Class and Control Class.

Class	St. Dev	N-Gain	Category
Experiment	0.10	0.62	Middle
Control	0.12	0.29	Low

The enhancement of students' HOTS scores is also clearly evident from the n-Gain results, which show a value of 0.69 in the experimental class and a value of 0.29 in the control class. The high n-Gain value in the experimental class is attributed to the use of Moodle-based STEM e-learning in facilitating student learning activities to enhance HOTS.

The Moodle-based STEM approach e-learning development product is also declared effective in stimulating students' Higher-order Thinking Skills (HOTS), as evidenced by the t-test results using SPSS 26. The results of the Average N-Gain Difference Test between the Experimental and the Control Class are presented in Table 5.

Table 5. Average N-Gain Difference Test between the Experimental Class and the Control Class.

		T-test for Equality of Means			
		T	df	Sig. (2-tailed)	Mean Difference
N-Gain	Equal variances assumed	10.253	47.000	.000	.32630
	Equal variances not assumed	10.301	45.424	.000	.32630

Based on the results of the t-test in the experimental class, a Sig value less than 0.05 was obtained, indicating a significant difference between the pretest and posttest scores in the experimental class. This means that after using the Moodle-based STEM approach e-learning development product, there was a change in students' Higher-order Thinking Skills (HOTS) before and after using the development product. This is supported by the result of the effect size in the experimental class, which has a "medium" criterion with a value of 0.43.

Dewi et al. (2020) assert that the teaching and learning process through STEM-based e-learning provides convenience for both teachers and

students in accessing information that can stimulate Higher-order Thinking Skills (HOTS). Based on relevant research, Baji et al. (2022) state that students who learn through STEM-based e-learning will acquire information more quickly from various sources available on the internet. E-learning has a significantly positive impact on students' thinking abilities. Sari et al. (2020) declare that E-learning has a very significant influence on enhancing Higher-order Thinking Skills (HOTS).

Learning through e-learning makes it easier for students to select and review topics they have not yet mastered. Compared to traditional classroom learning, e-learning offers several advantages, namely: 1) Online learning reduces the distance between teachers and students in various regions. Students can access information from anywhere and at any time (Herwiana & Laili, 2022). This is similar to previous findings that e-learning encourages flexible learning (Adi et al., 2021; Mutambik, 2018); 2) Online learning also provides benefits for students' character. Changing character to be positive is another impact of online learning. Students feel that online learning changes them to become disciplined and responsible (Herwiana & Laili, 2022). Other research supports that students become organized and disciplined by learning using technology (Aguilera-Hermida, 2020). Online learning can turn students into independent learners. This finding has the same results as previous research that technology can encourage independent learning (Mutambik, 2018; Saifuddin, 2018).

The development of Moodle-based STEM e-learning products is expected to enhance Order Thinking Skills (HOTS). The feasibility of the learning process can be observed from the students' questionnaire responses after participating in a series of learning activities using the developed Moodle-based STEM e-learning product. Based on the analysis of student responses to the learning experience, it falls into the category of "very high." This can be substantiated by students actively engaging in discussions using e-learning, posing questions, demonstrating enthusiasm to participate in learning activities, seeking out supplementary sources related to the subject matter, and displaying critical and creative thinking while solving presented problems with the assistance of e-learning, and their ability to express their outcomes in the form of graphs/tables. Effective learning depends on factors such as using external monitoring, where the teacher's role is an important part of this monitoring process. Teachers have typically been expected to actively participate during online learning, such as providing quick responses to student questions, organizing forum activities, communicating with students, and understanding the conditions of student learning. In addition to external monitoring, internal monitoring requires students to check in with their own learning needs and goals. They need to define the conditions and learning strategies that are suitable for their learning styles and needs (Hongsuchon et al., 2022).

Based on students' responses to the e-learning they have used, the development product is also deemed practical. The practicality of the Moodle-based STEM e-learning development product is also based on the completion of student response questionnaires after the implementation of learning activities using the Moodle-based e-learning development product. Student responses are assessed based on the aspects of effectiveness, attractiveness, efficiency, and ease of use in e-learning. The results of student responses to the implementation of the learning are presented in Table 6.

Table 6. The Student Response to the Implementation of E-learning.

No	Aspect	Average (%)	Criteria
1	Effectiveness	88.80	Very High
2	Attractiveness	88.54	Very High
3	Efficiency	90.10	Very High
4	Easiness	89.76	Very High
Average		**89.30**	**Very High**

The questionnaire-based test scored 89.30 %, revealing students' perceptions of the product's ease, attractiveness, effectiveness, and efficiency. Ease is evident in comprehensible e-learning guides, presentation flow, and easily digestible content like videos, e-modules, and worksheets. Attractiveness is reflected in layout design, language use, and image incorporation. Efficiency manifests in learning quality, achievements, problem-solving skills, and practical application of concepts, particularly notable in STEM-based e-learning.

E-learning is an electronic learning system conducted through online learning platforms over the Internet (Berestova et al., 2022). Aurora & Effendi (2019) assert that e-learning makes the learning process for students more engaging and interactive, without time constraints (Suharyat et al., 2022; Nuryatin et al., 2022; Lee et al., 2020). Saleem et al. (2021) state that e-learning helps cultivate interest and motivation in learning, enabling students to become more actively engaged in their studies. E-learning also makes student learning activities more effective and convenient due to its accessibility via the Internet (Krasodomska & Godawska, 2021). Furthermore, STEM-based e-learning has emerged as one of the solutions to enhance students' Higher-order Thinking Skills (HOTS). STEM is an instructional approach that integrates engineering, technology, and mathematics in its learning processes (Suharyat et al., 2022; Rahman et al., 2023; Eroglu & Bektas, 2021). The STEM approach assists students in enhancing their critical thinking skills (Friedensen et al., 2018). Furthermore, the research outcomes of Wijayanto et al. (2020) indicate that STEM education trains students to solve problems during their learning experiences.

The results also prove that Moodle-based e-learning provides a positive experience for students to enhance HOTS in terms of the quality of content, materials, and media displays presented. Also, the integration with the STEM approach to science learning is believed to improve the ability to achieve learning objectives. Even though STEM learning takes a long time, it turns out that it can be carried out using this product because, with Moodle-based e-learning, students can carry out learning anywhere and at any time. Thus, the application of learning using Moodle-based e-learning has a positive impact on students' learning outcomes.

CONCLUSION

Based on the research outcomes and discussions conducted, it can be concluded that the Moodle-based STEM e-learning product is capable of stimulating students' Higher-order Thinking Skills (HOTS) and is declared effective, as evidenced by an average n-Gain score categorized as "moderate" at 0.62 and an effect size categorized as "medium" at 0.43. This indicates that students' HOTS experience a significant improvement, starting from their abilities to analyze, evaluate, and create. Moodle-based e-learning products developed with a STEM approach are stated to be

practical in learning. This can be seen from student responses to learning, which has a "very high" category of 89.30 %. The practicality of the developed learning product is assessed based on its effectiveness, attractiveness, efficiency, and ease of using the Moodle-based e-learning platform.

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