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Advancement of STEM-Based Digital Module to Enhance HOTS of Prospective Elementary School Teachers

Dini Ramadhani[1], Ary Kiswanto Kenedi[1], Muhammad Febri Rafli[1], Ciptro Handrianto[2]

[1]Department of Primary School Teacher Education, Universitas Samudra, Indonesia

[2]Department of Pedagogy, Universiti Pendidikan Sultan Idris, Malaysia

*Corresponding email: arykenedi@unsam.ac.id

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Abstract: Advancement of STEM-Based Digital Module to Enhance HOTS of Prospective Elementary School Teachers. Objectives: The goal of this research was to develop a valid, practical, and effective STEM-based digital module to help prospective elementary school teachers enhance their HOTS**. Methods:** This was a development study employing a four-dimensional model. This study enlisted the help of five lecturers and 100 prospective elementary school teachers**. Findings:** The developed STEM-based digital module is declared to be highly valid to use with score obtained is 3.38 and also said to be highly practical to utilize, with a lecturer aspect score of 95.67 and a student aspect score of 91.37. The STEM-based digital module also is declared effective in strengthening the HOTS of prospective elementary school teacher students which received an N-Gain score of 0.69 in the medium category. **Conclusion:** The study's findings revealed that a valid, practical, and effective STEM-based digital module has been established to enhance the HOTS of prospective elementary school teachers.

Keywords: prospective elementary school teacher, digital module, STEM, HOTS.

Abstrak: Pengembangan Modul Digital Berbasis STEM untuk Meningkatkan HOTS Calon Guru Sekolah Dasar Judul artikel ditulis ulang disini. Tujuan: *Tujuan penelitian ini adalah untuk mengembangkan modul digital berbasis STEM untuk meningkatkan kemampuan HOTS calon guru sekolah dasar yang valid, praktis dan efektif.* ***Metode:*** *Penelitian ini merupakan penelitian pengembangan dengan menggunakan model 4-D. Penelitian ini melibatkan 5 orang dosen dan 100 orang mahasiswa calon guru sekolah dasar.* ***Temuan:*** *Penelitian ini menemukan bahwa modul digital berbasis STEM yang dikembangkan dinyatakan sangat valid dengan skor 3,38 dan juga dinyatakan sangat praktis digunakan dengan mendapatkan skor 95,67 untuk aspek dosen dan 91,37 untuk aspek mahasiswa. Penelitian ini juga menyatakan bahwa modul digital berbasis STEM efektif untuk meningkatkan HOTS mahasiswa calon guru SD dengan N-Gain 0,69 berkategori sedang.* ***Kesimpulan:*** *Hasil penelitian menyimpulkan bahwa telah dikembangkanya modul digital berbasis STEM yang valid dan praktis serta efektif untuk meningkatkan HOTS mahasiswa calon guru sekolah dasar.*

Kata kunci: *calon guru sekolah dasar, modul digital, STEM, HOTS.*

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INTRODUCTION

The emergence of the industrial revolution 4.0 has an impact on every aspect of human life. Education is one aspect that has an impact on the growth of the industrial revolution 4.0. The educational system faces several challenges and demands that must be met quickly in this era (Eliyasni et al, 2019; Helsa & Kenedi, 2019). The educational system is being challenged to apply a technology-based learning process. This is because we are living in an era of rapidly evolving technology and information systems, which serve as the foundation for people's daily activities. The education system, including the learning process, must be capable of transforming from a traditional to a modern education system (Hamimah et al, 2019; Hamimah et al, 2019). In the era of the industrial revolution 4.0, it is necessary to organize a technology-based learning process. Teachers must be able to incorporate technology into all aspects of the learning. It is hoped that students would be able to use and develop technology in all aspects of their lives.

In the realm of education, the challenges of the Industrial Revolution 4.0 era are primarily to meet demands. I t is essential for the educational system to generate graduates who are able to not only understand concepts but also to develop all of their skills, including thinking skills (Ahmad et al, 2018; Hamimah et al, 2020). Higher order thinking skills (HOTS) are one of the thinking abilities that are in need in the period of the industrial revolution 4.0 (Kenedi, 2018; Anita et al, 2020). Students with HOTS have a higher-level thinking skill that assists them solve challenges. HOTS is a type of thinking that necessitates unusual cognitive processes (NguyÅn & NguyÅn, 2017; Kwangmuang et al, 2021). HOTS is a method of thinking that entails the ability to analyse, evaluate, and create (Jarvis & Baloyi, 2020; Huang et al, 2022). In order to solve challenges, students must be able to think critically and creatively. HOTS is one of the skills that students must have in the industrial revolution 4.0, because in the future, students will be confronted with complicated challenges that will necessitate thinking processes that are not typical of problem-solving. As a result, every graduate, even future elementary school teachers, should be concerned with HOTS.

Students enrolled in the primary school teacher education department are considered prospective primary school teacher. In order to develop the HOTS of elementary school students while working, primary school teacher candidates must have a high HOTS. Teachers play a significant role in the development of elementary school students' HOTS (Erdimez et al, 2017; Susilowati & Suyatno, 2021). As a result, prospective elementary school teachers can expect to have a high HOTS. However, based on earlier research, researchers discovered that many prospective elementary school teacher students still have poor HOTS (Ramadhnai et al, 2021). This is due to the fact that university-based learning does not allow students to acquire HOTS. As a result, initiatives to develop the HOTS ability of prospective elementary school teachers are required.

HOTS can be developed as part of the learning process. Lecturers, as the responsible party, must be able to design a learning approach that will help future elementary school teachers develop their HOTS. The learning that is developed must also be adjusted to the characteristics of the 4.0 industrial revolution as well as the surrounding environment (Ilmi et al, 2020; Cotet et al, 2020). Learning using digital modules is one of the learning techniques that is in line with the industrial revolution 4.0 and student environmental conditions. The digital module is a type of learning in which students can access teaching materials electronically from

anywhere and at any time utilizing technology devices (UZ et al, 2019; Aprilia and Suryadarma, 2020). Because they require a technology system to access them, digital modules are ideal for usage in the industrial revolution 4.0. Furthermore, the digital module is well-suited to environmental conditions (the covid-19 epidemic), allowing students to study independently.

The researchers concluded from the literature study that the digital module had a substantial impact on improving the quality of learning (Linda et al, 2018; Afifah et al, 2018; Serevina et al, 2018; Saraswati and Linda, 2019). As a result, it is expected that the development of digital modules would raise the HOTS of prospective students. Digital modules are combined with STEM learning to ensure maximum results. STEM learning is a type of learning that incorporates elements of science, technology, engineering, and mathematics. STEM learning is a learning approach that is in line with the Industrial Revolution 4.0 since it incorporates technological aspects (Yang et al, 2020; Nurhayati, 2020). Furthermore, the researchers discovered that STEM learning was able to improve the quality of learning (Sengupta-Irving, 2019; Nuangchalerm, 2020; Hamdu, 2020). Based on the literature review, Researchers believe that incorporating STEM into digital modules can strengthen the HOTS abilities of prospective elementary school teacher students since the STEM learning process involves critical and creative thinking skills in solving problems from project activities carried out.

This study is a development of previous work. Researchers created a STEM-based digital module to improve student learning outcomes for primary school teacher education in a prior study (Hendri, Kenedi & Ramadhani, 2021). According to the study's findings, a valid and effective STEM-based digital module was designed to assist students enhance their learning outcomes. Previous study, on the other hand, focused on establishing STEM-based digital modules to improve learning outcomes among second-generation students majoring in primary school teacher education. This study differs from the previous one in that it focuses on the development of STEM-based digital modules to enhance the HOTS of prospective elementary school teachers. According to the researchers' literature assessment, there is no research that has investigated at the development of STEM-based digital modules to increase the HOTS of prospective elementary school teacher students. as a result, this research will be a new and valuable study. Therefore, it can be inferred that the goal of this study is to create a STEM-based digital module that is valid, practical, and effective in increasing the HOTS of prospective elementary school teacher students.

METHODS

The research model employed in this study is the 4-D model, and it is development research. The 4-D development model consists of four stages: define, design, development, and disseminate. A needs analysis is carried out during the define stage in the form of an initial analysis, a student analysis, and a material analysis. Activities such as planning a HOTS test and selecting a digital module format are carried out during the design stage. Digital module development, validity testing, practicality testing, and effectiveness testing were all done during the development stage. A digital module validation sheet, a practical questionnaire for teachers and students, and a HOTS ability test were utilized to collect data. The validation sheet evaluates factors of content feasibility, linguistic aspects, and presentational aspects. The practicality part of the sheet comprises of a response to the content's feasibility, appearance and content, as well as ease of use. The HOTS ability test was created

using the HOTS indications, which include analysing, assessing, and creating. The HOTS indicators used are analyze, evaluate and create. This indicator is taken from the opinion of Anderson and Krathwohl (2002). The analyze indicator is represented by 3 questions, the indicator evaluates 3 questions and the indicator creates 4 questions.

Experts examined all data collection instruments and confirmed them fit for use. The validity test data analysis technique is to calculate the average score and convert it into qualitative data using a four-point scale. If the score is more than 3.00, will get an A in the Best category. If the score obtained is less than 3 and the magnitude is equal to 2.50, the score is B in the Good category. If the score obtained is less than 2.50 and is equal to 2.00, the score is C in the adequate category. If the score obtained is less than 2.00, the score is D in the poor category.

If a minimum value of B is reached in the Good category, the feasibility value calculated in this study is B. Finding the average score is a significant data analysis tool. The average score is then transformed into fifth-point scale. If the score is between 90 and 100, it is categorized as highly practical. If the score is between 70 to 89, get a practical category. If the score is obtained between 50 to 69, it gets the Sufficiently practical category. If the score obtained is between 30 to 49, it is in the Impractical category and if the score is between 20 and 29, it is in the highly Impractical category. If a minimum score of 70-89 is reached in the practical category, the value of practicality is assessed in this study.

Calculating N-Gain with the formula is a data analysis strategy for increasing students' HOTS abilities. The results of N-gain are then converted. If the g value obtained is more than 0.7, it is categorized as high. If the g value obtained is more than 0.3 and small is equal to 0.7, it is in the middle category and if the g value is less than 0.3, it is in the low category. The gain value determined in this study if the g score get a medium category.

RESULTS AND DISCUSSION

This research begins with the define stage. A needs analysis is carried out at this stage, which includes an initial analysis, student analysis, and material analysis. The goal of the initial analysis is to determine the most important foundation for producing STEM-based digital modules. The fundamental motivation behind the development of this digital module is that efforts are required to improve the HOTS of prospective elementary school teacher students based on student and environmental characteristic. In the industrial revolution 4.0, the student environment necessitates a technology-based learning process (Dewi et al, 2019; Eliyasni et al, 2019) . As a result, the use of digital modules might be considered a type of technology-based learning. Furthermore, the situation in Indonesia, which is still dealing with the COVID-19 pandemic, necessitates the use of an online learning system (Daniel, 2020). Another reason to make this a supporting factor in the development of this digital module is because of this. The STEM approach was used to create this digital module. STEM was chosen because it contains technological components that characterize the industry 4.0 (Putri et al, 2020; A;l-Taweel, 2021). STEM was also chosen because it is a type of integrated learning that is contextual in nature, making it suitable for future elementary school teachers (Rochim et al, 2021). This will serve as the foundation for the creation of STEM-based digital modules aimed at improving the HOTS of future elementary school teachers. The next step is to evaluate students who are interested in becoming elementary school teachers. Its goal is to figure out how students are doing. The purpose of this student analysis is to determine whether or not

students are ready to use digital modules. All prospective elementary school teacher students had laptops and PC devices, according to the questionnaires supplied. Students are also used to using a learning management system (LMS) to take online programs. Students are more interested in learning how to utilize digital modules than they are in learning how to use print modules. This shows that students interested in becoming primary school teachers are prepared and capable of using the digital modules that will be developed. Following the analysis of the students, the material analysis was conducted. The purpose of material analysis is to determine which materials will be transformed into STEM-based digital modules. Numbers, fractions, comparisons, patterns, distance, time, and speed are among the topics covered in the content provided for high school mathematics learning courses.

The design stage is the next stage. The goal of this stage is to plan out the development of digital modules. The phases of building the HOTS instrument and systematic development of a digital module make up this stage. The HOTS instrument is made up of ten questions that are specialized to the HOTS indicators: analysing, assessing, and creating. Experts then validated the question and pronounced it fit for use. The digital module format is then chosen. Based on the agreement, the digital format that will be used in this research is cover, introduction, table of contents, about the module, learning objectives, material description (containing understanding activities, STEM activities, discussion activities and STEM information), summary, exercises, answer keys, feedback, and follow-up.

The development stage is the next step. The development of STEM-based digital modules for prospective elementary school teachers is now underway. The digital module is based on the design that has been completed and adjusted to the needs analysis results. The validity of the system must be tested after it has been developed. The purpose of the validity test is to see if the digital module being produced is feasible. Experts in materials and media are involved in this test. There are two times for validation activities. The results of the validation tests are summarized in the table below:

Table 1. Recapitulation of validation test results by experts

Test	Aspects	Validation 1			Validation 2		
		Value	**Average**	**Category**	**Value**	**Average**	**Category**
Material	Content Feasibility	2.30	2.31	Adequate	3.15	3.27	Highly valid
	Language	2.45			3.43		
	Presentation	2.18			3.23		
Media	Screen design	2.40	2.46	Adequate	3.48	3.50	Highly Valid
	Ease of use	2.38			3.74		
	Consistency	2.76			3.65		
	Benefits	2.15			3.19		
	Graphics	2.65			3.48		
Conclusion			2.38	Adequate		3.38	Highly Valid

Table 1 shows that the validation activity's final result is extremely valid, with an average score of 3.38. This demonstrates that the STEM-based digital module that is being built is very feasible. A practical test is the next activity. The purpose of the practicality test is to see how practical STEM-based digital modules are. Lecturers and students were subjected to this practicality test.

The results of the practicality test for the lecturer aspect receive a score of 95.67 in the highly practical category and a score of 91.37 in the highly practical category for the student aspect. According to these findings, STEM-based digital modules are very practical for lecturers and students to use. The effectiveness test is the next activity. The purpose of the effectiveness test is to see if STEM-based digital modules can help prospective teacher students enhance their HOTS. Students are given HOTS questions as part of the effectiveness test. Before using the STEM-based digital module and after using the STEM-based module, HOTS questions are given. The N-Gain method is then used to calculate the improvement based on the score values. The following is a recapitulation of student HOTS scores.

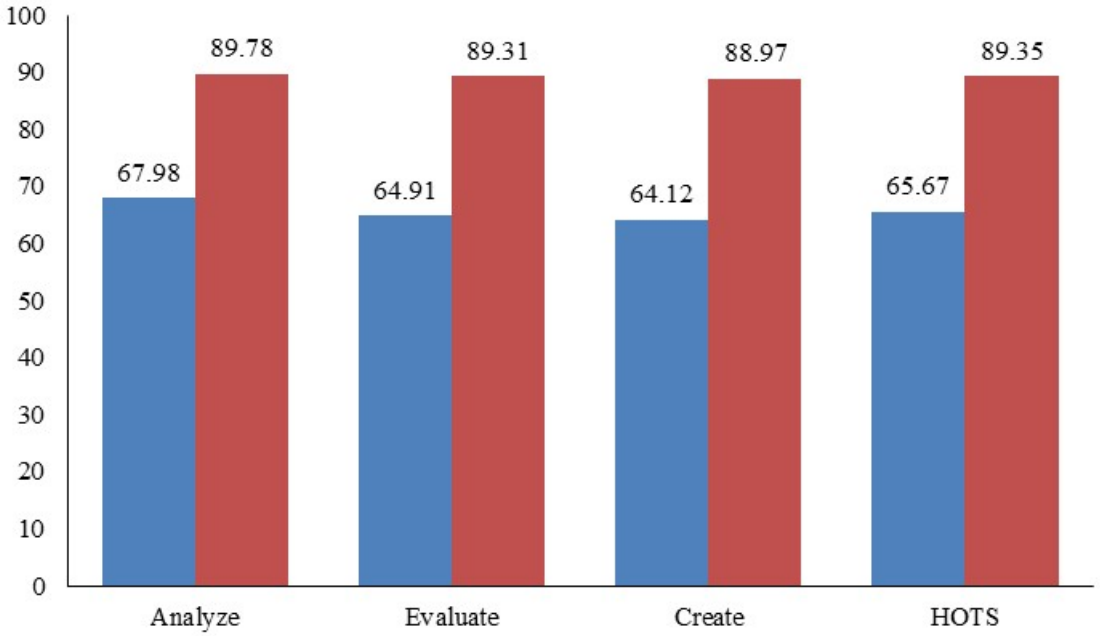

Figure 1. Recapitulation of pretest (blue) and posttest (red) score

After obtaining the pre-test and post-test scores, the N-Gain was calculated. The results of the N-Gain calculation are adjusted to the HOTS indicator. The analyze indicator gets a g value of 0.68 in the middle category. The evaluate indicator gets a g value of 0.69 in the middle category. The create indicator gets a g value of 0.69. The total of all HOTS indicators got a g value of 0.68 in the middle category. This demonstrates that employing STEM-based digital modules, prospective elementary school teacher students' HOTS skill improves. This finding suggests that the STEM-based digital module developed is effective in raising the HOTS of future elementary school teachers.

Based on the data, it can be concluded that the STEM-based digital module produced is both valid and feasible to use, and that it effectively

raises the HOTS of future elementary school teachers. In the era of the 4.0 industrial revolution, HOTS is a critical skill (Arbia et al, 2020; Jaenudin et al, 2020). This is due to the fact that HOTS makes it easier for people to solve difficult problems and make wise decisions. This study demonstrates that the proposed STEM-based digital module is extremely practical to utilize. This is due to the fact that the digital module created is adjusted to the content's feasibility.

STEM-based digital modules are created using resources and learning objectives that are appropriate for the level of the students. This is in line with the opinion that when developing a module, it is critical to consider the material's suitability for the learning objectives (Martingisih et al, 2019; Rahayi and Sukardi, 2021). This digital module was also created with the material's systematic arrangement and sequence. The material presented evolves from simple to complicated, guiding students' mindsets away from simplistic thinking and toward higher-order thinking processes. This is in line with the opinion that it is required to arrange sequential and systematic material in module development (Jamel et al, 2019; Setiyani et al, 2020). The feasibility of this digital module is also affected by material development. The created material is given in a contextualized manner and is adjusted to the degree of student understanding. This is in line with the opinion that material in a module should be presented in a straightforward and adaptable way to the degree of student growth (Kusyanti, 2021; Farihah and Norawi, 2021). Furthermore, material is created in this digital module by merging HOTS parts. There is a section in this module that demands students to analyse, assess, and create. This element can take the shape of a thinking or an action. This is what makes this digital module unique. The goal of incorporating HOTS features is to get students used to and trained to think in unexpected ways. This is in accordance with the claim that including HOTS aspects into the learning process will help students think more critically (Widana et al, 2018; Sing et al, 2020).

The linguistic aspect that is being developed has an impact on the feasibility of this STEM-based digital module. This digital module's material was written in an easy-to-understand style for students. The language has been modified to help students grow, and it follows the Indonesian language guidelines that have been established. This is consistent with the assertion that it is essential to pay attention to the language component while building a module so that the material delivered is easily comprehended by students (Setiyani et al, 2020; Abi et al, 2017). Furthermore, the presentation aspect of this STEM-based digital module has an impact on its feasibility. Exercise and practice questions are presented in this digital module in accordance with the material. The exercise and practice questions provided are also applicable to the material being prepared. This is consistent with the concept that a module should include exercise questions and practice questions that are relevant to the topic (Serevina et al, 2018; Fisnani et al, 2020).

The media aspect is also considered in the feasibility of this STEM-based digital module. The screen design was taken into consideration when creating this digital module. The colour of the text was combined with the proper background to create this module. The proportional layouts of each part of the module are also taken into account in order to attract students. Every aspect of illustration, graphic design, and colour integration is studied. This is done to make the screen design more appealing. This activity is supported by a statement that suggests that the screen design is essential to consider while developing a digital display module (Musliimin et al, 2017; Everaert and Safari, 2021).

Furthermore, this digital module was created with ease of use in mind. The module is arranged into sections that are both coherent and clear. The module also includes multimedia content that is simple to use for students. There are clear and simple navigation menus for students to understand. This is consistent with the assertion that "user convenience is a critical factor in the creation of digital modules" (Setiyani et al, 2020; Mahas et al, 2021).

Consistency is also an important factor to consider. Every word, term, and sentence in the module is written in consistent and standard language guidelines. This is in line with the statement that module development should take consistency into account. The usability of digital modules should also be taken into account (Iqbal et al, 2022; Qotimah, 2022). The purpose of the digital modules is to increase HOTS. This module is designed to help you attain HOTS in every way. This is in accordance with the concept that a module should be built while considering issues of user convenience. Font size, colour resolution, image proportionality, multimedia fluency, and well-developed narration are all taken into account in the module's graphics. This is due to the fact that the graphic aspect will have an impact on students' visualization (Serevina et al, 2018; Utomo et al, 2020). This research shows that the developed STEM-based digital module is really practical. This practicality is inextricably linked to the development process, which considers content feasibility, appearance, content, and user convenience. This is in agreement with the idea that it is necessary to pay attention to the practicality of content, appearance and content, as well as ease of use, when developing the module (Serevina et al, 2018; Utomo et al, 2020).

This study demonstrates that the designed digital module is effective in raising the HOTS of prospective elementary school teachers. This is because material in this module requires students to be able to analyse problems, assess difficulties, and design solutions in order to solve problems. This module requires students to not only think, but also to blend cognitive, affective, and psychomotor abilities in order to activate higher-order thinking processes. This module includes project activities to help students create HOTS. This subject is also enhanced by the inclusion of examples of HOS questions. Students must analyze, assess, and create in order to answer some of the questions that have been generated. To make it easier for students to direct the HOTS process, sample questions are accompanied with answers. This is in conformity with the concept that students must be familiar with HOTS practice questions when developing HOTS (Dasvila et al, 2019; Kuseari et al, 2019; Tanudjaya & Doorman, 2020). Furthermore, the exercises offered in this module are responsible for the increase in student HOTS. Students must be able to think critically in order to complete the assignments. These are the characteristics that make STEM-based digital modules valid, practical, and effective in enhancing the HOTS of future elementary school teachers.

CONCLUSIONS

The developed STEM-based digital module is declared to be highly valid to use, according to the findings of this study. With a highly valid category, the score obtained is 3.38. The STEM-based digital module is also said to be highly practical to utilize, with a lecturer aspect score of 95.67 and a student aspect score of 91.37. The STEM-based digital module is also effective in strengthening the HOTS of prospective elementary school teacher students, according to this study, which received an N-Gain score of 0.69 in the medium category. The developed STEM-based digital module is proclaimed to be highly valid to use, according to the findings of this study.

The implications of this research can be used as a reference in developing digital modules for college students. In addition, this research can be used as an effort to develop student HOTS in higher education. This study has limitations, namely the study of effectiveness is only within the scope of one university. A thorough assessment of the effect of STEM-based digital modules is required.

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