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INTERACTIVE DIGITAL MODULE DEVELOPMENT FOR MATHEMATICAL REPRESENTATION SKILLS USING A CONTEXTUAL LEARNING APPROACH

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Abstract

The need for technology-based teaching materials that align with online learning environments has significantly increased in the past two years. This shift has led to the transition from traditional teaching resources to digital learning materials. This study aims to develop an interactive digital module focused on statistical material by contextualizing students' representational skills. This type of research is a research design with a development study type, which included preliminary and formative evaluations—namely self-evaluation, prototyping, and field testing. The participants of this study were eighth-grade students from Middle School 3 Metro. Data were collected using observation sheets, interviews, and student assessments. The results indicated that the interactive digital module met the "very feasible" category, as shown by material expert validation results of 85.71%, media expert validation of 90.6%, and teacher validation of 81.57%. Furthermore, the student's average mathematical representation ability test score was 75.65. These findings suggest that the developed interactive digital module is appropriate for supporting the teaching and learning process in mathematics, particularly in statistics. The module can serve as an effective tool to enhance students' conceptual understanding through contextual and interactive digital content.

Keywords *: Interactive Digital Module, Contextual Approach, Mathematical Representation Ability*

Abstrak

Kebutuhan akan bahan ajar berbasis teknologi yang selaras dengan lingkungan pembelajaran daring telah meningkat secara signifikan dalam dua tahun terakhir (Sakiah & Effendi, 2021; Sumargiyani & Tsani, 2024). Pergeseran ini telah menyebabkan transisi dari sumber belajar tradisional ke bahan ajar digital. Penelitian ini bertujuan untuk mengembangkan modul digital interaktif yang berfokus pada materi statistika dengan mengontekstualisasikan keterampilan representasi siswa. Proses pengembangan mengikuti metodologi penelitian desain dengan pendekatan studi pengembangan, yang mencakup evaluasi awal dan formatif, yaitu evaluasi diri, pembuatan prototipe, dan uji lapangan. Subjek dalam penelitian ini adalah siswa kelas VIII SMP Negeri 3 Metro. Data dikumpulkan melalui lembar observasi, wawancara, dan asesmen siswa.

Hasil penelitian menunjukkan bahwa modul digital interaktif termasuk dalam kategori "sangat layak", ditunjukkan oleh hasil validasi ahli materi sebesar 85,71%, validasi ahli media sebesar 90,6%, dan validasi guru sebesar 81,57%. Selain itu, rata-rata nilai tes kemampuan representasi matematis siswa sebesar 75,65. Temuan ini menunjukkan bahwa modul digital interaktif yang dikembangkan sesuai untuk mendukung proses pembelajaran matematika, khususnya pada materi statistika. Modul ini dapat menjadi alat yang efektif untuk meningkatkan pemahaman konsep siswa melalui konten digital yang kontekstual dan interaktif.

Kata Kunci*:* Modul Digital Interaktif, Pendekatan Kontekstual, Kemampuan Representasi Matematis

INTRODUCTION

Education is a need that every individual needs to improve and explore the potential that exists in the world (Marteney & Bernadowski, 2016). With education, a person is equipped with various knowledge, skills and is no less essential with a good life order in the form of norms, favorable rules, and so on. That way, there are teaching and learning activities where teachers and students are essential components. Learning is a process of changing behavior and changing understanding; at first, a child is not equipped with natural potential, then with the learning process, a child will increase his understanding (Kurz et al., 2015). Teachers must recognize the characteristics of each student in order to know how to learn or the learning process that can make it easier for students to accept and understand the subject matter. The proper learning process and easy-to-understand students can improve each individual's ability (Hardiyanti & Azizah, 2019).

Learning mathematics today requires an educator who is highly dedicated to carrying out his professional duties. The weak learning process is a problem that often arises in education. To achieve the objectives of learning mathematics, students need experience in completing a mathematical solution so that students can experience how to solve the problem (Stohlmann & Albarracín, 2018). Statistics is one of the materials that must be taught to students in learning mathematics. This is because statistics is a branch of mathematics that helps a lot in human life (Yensy, 2020); because of its nature that helps human life, statistics have been used in trade, business, education, and decision-making in politics. In addition, students' mathematical representation skills are needed to communicate mathematical ideas and implement them into statistical material.

Representation is a model or substitute form of a problem situation used to find a solution. For example, a problem can be represented by objects, pictures, words, or mathematical symbols. The representations raised by students are expressions of mathematical ideas or ideas displayed by students in their efforts to find a solution to the problem they are facing (Boaler et al., 2016). So, representation is a form of interpretation of students' thoughts on a problem that is used to find a solution to the problem. Representation skills need to be improved in learning (Wu et al., 2018) because it can help students understand mathematical concepts through drawing, using objects, providing reports, and verbal explanations. Students' mathematical representation ability is a

cognitive ability that affects mathematics learning outcomes and student achievement (Yulinawati & Nuraeni, 2021). Students' representation ability is a measure of success in learning mathematics. If students have weak representational abilities, solving the problem will be hampered (Stull et al., 2016). Therefore, the ability of representation plays a vital role in determining how students' attitudes towards a problem, especially math problems.

As educators and prospective educators, they should develop teaching materials that can help students understand a concept, complete teaching resources, and improve students' mathematical representation abilities. So far, the teaching materials used in schools come from textbooks provided by the government, so they are not entirely in line with the characteristics of students in schools. Teaching materials are more meaningful when they relate to real contexts in everyday life (Laurens et al., 2018). Teaching materials will be easier to understand through material based on experience and observations of the problems of everyday life. The learning process is carried out by connecting the problems in everyday life or the student's environment (Nagy et al., 2018). Linking learning materials to everyday life is a form of contextual learning. Contextual learning is a learning system that matches the brain to generate meaning by connecting academic content with students' daily lives (Barus & Simanjuntak, 2020). For example, in learning statistics, students can analyze real-world data, such as the average daily temperatures in their city, the distribution of household expenses, or survey results of students' favorite extracurricular activities. By analyzing real data, students can better understand concepts like mean, median, mode, and data distribution, making statistical concepts more tangible and relevant to their everyday experiences.

In learning mathematics using a contextual approach, teachers need to develop teaching material that can overcome problems in the learning process (Huang et al., 2020). One of them is with modules and the use of technology in today's modern era. Print modules whose presentation has been transformed into electronic form, thus giving birth to a term called digital module or e-module. Thus, the digital module can be defined as one of the appropriate learning alternatives for students (Stohlmann & Albarracín, 2018) because it can help students to add information about the concepts learned through systematic learning activities. Digital modules made in attractive and easy-to-understand language and using a contextual approach are expected to make it easier for students to understand the mathematical concepts contained in the material (Susanti et al., 2020). Digital module with a contextual approach is expected to be helpful to facilitate students in learning mathematics, particularly in understanding statistical concepts. Through contextual learning, abstract statistical ideas such as data collection, representation, analysis, and interpretation can be linked to real-life situations, enabling students to grasp the relevance and application of statistics in everyday life. Utilizing technology such as computers, laptops, and smartphones brings interactive digital modules. It changes the presentation of modules usually printed into modules that can be read without being printed.

The digital era and the rapid and increasingly sophisticated technological advances that are happening today are starting to innovate and develop learning modules in digital form. The interactive digital module is one of the learning media that allows users to interact intensively and not be bound by space and time (Bryson & Andres, 2020). Digital-based media engenders users in engaging with the content or substance being studied (Pujasari & Ruslan, 2021). Interactive digital modules in learning can create more engaging learning that is not bound by space and time, as well as easy access when needed. The interactive digital module has a different appearance because it is compiled with digital services that have practical advantages and are easy to use. In addition, it is equipped with pictures and learning videos that can attract students to learn it.

METHODS

This research uses design research type of development study and is intended to produce a product in the form of an interactive digital module based on a contextual approach to mathematical representation skills in class VIII statistics material. The module developed uses the Flip PDF Professional application. The development procedure carried out by the researcher refers to the Tessmer model with preliminary and formative evaluation stages (Tessmer, 1993). The formative evaluation stage includes the self-evaluation, prototyping (expert review, one-to-one, and small group) stages, and field tests. Expert reviews involved in this research are material experts and media experts.

Data collection techniques used are, document, walkthroughs, observations and interviews, and tests. Documents are used in the preliminary, self-evaluation, and field test stages. The walkthrough was carried out to collect suggestions and comments from expert reviews to assess an interactive digital module made. Observations and interviews were used to obtain data in the form of input from one teacher in the one-to-one stage, three students in the small group stage, and one class in the field test. The test is used to obtain data on students' representation abilities after using the module.

The data collection instruments used in this study were: (1) expert validation sheets used to measure the validity of interactive digital modules; (2) Student response sheet in the form of a questionnaire which aims to determine the response to the developed digital module. Data analysis was carried out to determine the feasibility and student responses based on the practical aspects of the developed interactive digital module.

RESULTS AND DISCUSSION

The researcher's development procedure refers to the design research type of development study. The preliminary study stage was carried out to obtain information about the needs of student learning materials that support the learning process. The analysis in this study was carried out in three ways, namely: (a) Needs analysis by

interviewing one of the teachers of SMP Negeri 3 Metro; (b) Analysis of the material in this study was carried out through observation and review of the syllabus and several books, particularly the 2017 revised edition of the Mathematics textbook for class VIII Semester 2 published by the Ministry of Education and Culture. The book is a student learning resource used in SMP Negeri 3 Metro. The data obtained will be used as a reference as material in digital modules; (c) Analysis of student characteristics in this study aims to determine the level of various student abilities through interviews with one of the class VIII teachers at SMP Negeri 3 Metro. After studying the literature and analyzing student characteristics, module design was carried out to design the developed interactive digital module product framework. The presentation of this interactive digital module is arranged sequentially and consists of three parts: introduction, content, and closing. The conceptual design at the preliminary study stage is transformed into a product in the form of an interactive module ready to be implemented.

The next stage is self-evaluation. The presentation of interactive digital modules is composed of three parts, namely (a) Introductory section consisting of cover, preface, table of contents, instructions for using digital modules, study steps, and instructions for working on questions; (b) The content section consists of a presentation of material about statistics (data presentation, mean, median, mode, and distribution of data), examples of questions that contain representational abilities and relate them to everyday life, practice questions to train students' abilities, as well as there, is video material to help students if they still have difficulty learning the material; (3) The closing section consists of a summary of the material and a brief author background.

At the stage expert review, prototype digital module is analyzed by expert review. The analysis was carried out by two expert reviewers to assess the extent to which digital modules are appropriate for use based on assessment indicators. The two people provided corrections or input regarding materials and media in the digital module. In line with the assessment by the expert review, the one-to-one stage was also carried out for math teachers who teach in schools. The results of the evaluation by the three people are shown in Table 1.

Table 1. Validation Result Digital Module

	Material Expert	Media Expert	Teacher
Score	85,71	90,60	81,57
Description	Very Good	Very Good	Very Good

The description in Table 1 is obtained from the validation criteria interval as shown in Table 2 (Putri, 2019) :

Table 2. Validation Criteria Interval Digital Module

Validation score obtained (x)	Criteria for media
$80\% < x \leq 100\%$	Very good
$60\% < x \leq 80\%$	Good
$40\% < x \leq 60\%$	Sufficient

$20\% < x \leq 40\%$	Poor
$0\% < x \leq 20\%$	Very bad

Material experts suggest adding ways to change data from percent to degrees, including the mean formula, swapping several pages in the video, and doing exercises according to the material. The advice given by media experts is to add pictures according to the example and add motivational words to the title.

Digital module prototypes that have been repaired based on expert suggestions are then brought to the small group stage. Three students with high, medium, and low mathematical abilities were selected at this stage. This ability is selected based on suggestions from the teacher who teaches the class. The digital modules were given to them (three students) to see the effectiveness of the modules from various levels of student difficulty. Some suggestions and input from students regarding displaying digital modules, material and evaluation of questions, selection of images in illustrations, and examples from everyday life are materials for improvement in the small group stage.

In the final stage or field test, the digital module, which has undergone several revisions, is given to a class of students in grade VIII middle school of 3 Metro, totaling 32 people. After learning in two meetings, students are asked to work on questions at the end of the module to find out their mathematical representation abilities after using the module. The practice questions consist of five representation ability questions. The scoring results per indicator of representation ability are shown in Table 3.

Table 3. Mathematical Representation Indicators

Indicator	Score
Representing data/information from a representation to a representation of a diagram, graph, or table	60,48
Use visual representations to solve problems	90,32
Create equations, mathematical models, or representations of other representations given	94,35
Solve problems by involving mathematical expressions	83,06
Write down the steps for solving math problems in words	50,00
Mean	75,65

Based on the results of these tests, the students' representational ability looks relatively high, where can be seen from the data presented in Table 3, where the indicators "Use visual representations to solve problems" and "Create equations, mathematical models, or representations of other representations given" achieve scores of 90.32 and 94.35, respectively. So interactive digital modules can make students understand mathematical representation abilities. The results from the first and fifth indicators, namely "Representing data/information from a representation to a representation of a diagram, graph, or table" with a score of 60.48, and "Write down the steps for solving math

problems in words" with a score of 50.00, indicate areas that require further improvement. These findings can serve as a basis for recommendations in future research. Researchers could explore effective strategies or interventions to enhance students' abilities in visual representation and verbal explanation of mathematical problem-solving steps. This could include the development of targeted learning modules, interactive visual tools, or contextual learning activities that specifically address these skills. These results are relevant to previous research conducted by Della Alifya Hastin. Explains that developing digital modules assisted by Sigil Software with a realistic mathematical approach is valid and feasible (Hastin, 2020).

PENUTUP

Conclusion

The development of an interactive digital module was carried out using a design research methodology with a development study type, consisting of two main stages: a preliminary study and a formative study. The formative study included: (1) self-evaluation through a thorough review of the module prototype, (2) expert review assessments on content and media, (3) one-to-one evaluation by a teacher, (4) assessment by three students with different levels of mathematical ability, and (5) whole-class evaluation by a group of students. The contextual-based interactive digital module developed in this study effectively supports students in understanding mathematical representation skills, particularly in statistical material. The module can be accessed at https://bit.ly/4jQX1Ho.

Recommendations

Based on the findings, it is recommended that the developed interactive digital module be utilized more widely in mathematics instruction—not only limited to statistics but also for other relevant topics. Teachers are encouraged to use this module as an alternative teaching material that is interactive and contextually grounded to enhance students' conceptual understanding. Future research may consider developing similar modules for other mathematical topics and conducting experimental studies to evaluate their effectiveness in improving student learning outcomes more comprehensively.

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