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Development of a E-Modul Penyajian Data to Enhance Students Mathematical Conceptual Understanding and Reduce Mathematics Anxiety

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Abstract

This research aims to produce a Grade VII E-Modul Penyajian Data oriented toward students' mathematical concept understanding and mathematics anxiety. The quality of the developed e-Module refers to Nieveen's criteria, namely validity, practicality, and effectiveness. This study uses a development research design with the 4D model (Define, Design, Development, and Disseminate). The research subjects consisted of 30 Grade VIIc students at a school in Sleman Regency. The instruments used included validation sheets, teacher and student assessment sheets, observation sheets for learning implementation, mathematical concept understanding test items, and a mathematics anxiety questionnaire. The e-Module is categorized as valid if the validator's assessment reaches at least the "good" category. It is considered practical if teacher assessments, student assessments, and learning implementation observations are also at least in the "good" category. The e-Module is declared effective if there is an increase in students' mathematical concept understanding and a decrease in their mathematics anxiety. The results of this development research produce a Grade VII E-Modul Penyajian Data oriented toward students' mathematical concept understanding and mathematics anxiety that is valid, practical, and effective. Validator assessments meet the validity category, namely "good". Teacher and student assessments each meet the practicality category, namely "very good" and "good", and the learning implementation observation sheet also meets the "very good" practicality category. Both test results also show that the E-Modul Penyajian Data is effective in terms of students' mathematical concept understanding and mathematics anxiety. Based on the results of the paired t-test, there was an increase in the average ability to understand mathematical concepts and a decrease in the average level of students' mathematical anxiety.

Keywords: *E-Module Mathematics; Problem Based Learning; Mathematical Conceptual Understanding Skills; Math Anxiety*

Introduction

Mathematics learning in school aims to enable students to understand mathematical concepts in depth. According to Pujiadi (2016), this goal includes students' ability to understand concepts, recognize patterns in problem solving, make generalizations based on data, conduct reasoning, communicate mathematical ideas, and utilize teaching aids and technology in mathematics activities. Understanding math concepts is important because it allows students to solve new problems and becomes the basis for subsequent learning (National Council of Teacher of Mathematics, 2000).

However, data shows that students' understanding of mathematics concepts in Indonesia is still relatively low. Hoiriyah (2019) It was reported that only 33.25% of students were able to solve math problems correctly, while 62.75% had difficulties. Data from the 2015 Trends in International Mathematics and Science Study (TIMSS) also ranked Indonesia 44th out of 49 countries in mathematics learning, with low scores, especially in algebra, geometry, and data presentation materials (Mullis et al., 2016). The results of the Programme for International Student Assessment (PISA) 2022 also show that Indonesia is in the 67th position out of 79 countries with an average mathematics score of 366, far below the PISA average of 469 (OECD, 2023).

This low understanding of mathematics concepts has an impact on students' interest in mathematics and increases student anxiety. Setiawan, Pujiastuti, and Susilo (2021) revealed that math anxiety makes students feel inadequate, anxious, and even refuse to learn math. Olaniyan and Merdinat F (2015) found that math anxiety was negatively correlated with interests and achievement, where anxious students tended to find math difficult and disliked it. Other research has also shown the negative impact of anxiety on students' learning outcomes and understanding of mathematical concepts (Diana et al., 2020; Ikhsan, 2019). In addition, research by Luthfiyah and Hadi (2021) and Supriatna & Zulkarnaen (2019) shows that mathematics anxiety in junior high school students is higher than in high school students, so it requires serious attention in learning mathematics at that level. If this problem is left unchecked, mathematics anxiety has the potential to reduce students' critical thinking skills and interest in careers that require mathematical competence, which can ultimately affect the competitiveness of Indonesia's young generation.

As one of the effective solutions, Problem Based Learning (PBL) is proposed to improve students' understanding of mathematical concepts. According to Fariana (2017), PBL can improve understanding of mathematical concepts, while Rismanto et al. (2020) report that PBL helps reduce math anxiety in students. Martiasari & Kelana (2022) also found that PBL significantly improved students' ability to comprehend mathematical concepts with an average score of 89 in the "very good" category. In addition to the learning model, the use of teaching materials in the form of modules, especially e-modules, is also considered potential in improving understanding of concepts and reducing mathematics anxiety. Research by Anggraini et al. (2022) and Fitriwanti et al. (2023) shows that valid, practical, and effective e-modules can improve students' understanding of mathematical concepts and independent learning. Stuart (2018) also stated that the use of modules is able to reduce students' mathematical anxiety and meet the criteria of validity, practicality, and effectiveness in learning.

Although there have been various teaching materials for modules that have been developed, research that specifically focuses on improving understanding of mathematical concepts while reducing mathematical anxiety through the use of e-modules is still rare. The government and curriculum developers have made efforts to improve the quality of mathematics teaching through curriculum updates and the provision of supporting tools, including e-modules. E-modules have characteristics such as self-contained, self-instructional, stand alone, adaptive, and user-friendly (Ontario Ministry of Education, 2005), and offer advantages in the form of multimedia interactivity and easy access for students and teachers (Herawati & Muhtadi, 2018; Laili et al., 2019).

Based on pre-research observations in one of the schools in Sleman Regency, it is known that teachers still use Student Activity Sheets (LKS) and mathematics package books as the main means of learning without utilizing e-modules. The available package books are not enough for the needs of all students, and both students and teachers have difficulty in utilizing the worksheets and package books. The use of these traditional teaching materials takes longer and is less effective in achieving the desired competencies in a limited time. Therefore, e-modules that are integrated with the PBL method are expected to overcome this obstacle by providing teaching materials that are more accessible, interactive, and effective in improving understanding of mathematical concepts and reducing students' mathematical anxiety.

With this background, this research aims to develop an e-module that is integrated with the PBL

method to improve understanding of mathematical concepts and reduce students' anxiety effectively. This research, entitled "Development of E-Modules to Improve Students' Ability to Understand Mathematical Concepts and Reduce Students' Mathematical Anxiety," is expected to be the right solution in overcoming mathematics learning problems in Indonesia.

Methods

The research conducted is a type of Research and Development (R&D) research. According to Sugiyono (2013) Research and Development (R&D) is a research method used to produce a specific product and test the effectiveness of that product. The development model used in the research is development with 4-D models (Four D Models) consisting of Define, Design, Develop and Disseminate. In the Definition stage, the initial and final analysis through teacher interviews, student interviews, and classroom observations shows that Data Presentation learning is still teacher-centered and students need interactive media that is easily accessible. Student analysis revealed that most students had a low initial understanding of the type of data and the form of its presentation. Concept analysis maps the Data Presentation curriculum into core concept groups: data types, data collection techniques, and data presentation in tables, bar charts, line charts, and pie charts. The assignment specification matrix is compiled based on learning outcomes and learning objective indicators to ensure the integration of the material with the Problem-Based Learning (PBL) model.

At the Design stage, the e-module storyboard is prepared to determine the layout, navigation, and content of the Data Presentation material using the Flip PDF Corporate Edition application, with the final format in the form of a PDF link that can be accessed via smartphone. The research instruments were developed including a concept comprehension test (multiple choice) and a mathematical anxiety observation sheet, both of which were compiled based on an indicator grid and validated by two subject matter experts and two media experts. The e-module specifications include material components, sample questions, Wizer.me-based formative tests, summaries, and integration with the Problem-Based Learning model. The e-module development matrix, pre-test–post-test questions, and observation sheets are completed as the main outputs of the design stage. The development stage includes the creation of a E-Modul Penyajian Data, product validation, limited trials, and extensive trials.

The Development Phase involves creating e-modules through content design in Canva, integrating interactive buttons in Flip PDF Corporate Edition, and finalizing in interactive PDF format. The product is validated by subject matter experts and media experts using standard validation instruments, then revised according to input. The e-module underwent two stages of testing: a limited trial to assess readability and practicality, and a broad trial to test the effectiveness of its use in Data Presentation learning.

The dissemination stage is carried out by disseminating the e-Modul Penyajian Data product that has been developed to mathematics teachers. After getting the final product, which is in the form of suitable teaching materials, it will be disseminated by giving it to teachers at the school where the data is taken.

The trial was carried out in one of the schools in Sleman Regency in the even semester of the 2023/2024. The subjects in the limited trial were six students in Grade VII. The subject of the field trial involves one class with a total of 30 students, namely students who are in Class VII. Data collection techniques use both tests and non-tests. The instruments used in this study were validation sheets, assessment sheets by teachers and students, observation sheets on learning implementation, test questions for mathematical concept comprehension skills and student mathematics anxiety questionnaires.

The data obtained from experts is analyzed to answer whether the e-modules developed are valid from the theoretical strength. Meanwhile, the data from the field trial results are used to answer the criteria for practicality and effectiveness of the developed e-module. Data in the form of comments, suggestions, revisions, and observation results during the trial process were analyzed descriptively qualitatively and concluded to revise the developed product. Meanwhile, data in the form of expert response scores, teacher assessment scores, student assessment scores and student learning outcomes were analyzed quantitatively descriptively. Sa'dun (2013) classify the scoring conversion from quantitative data to qualitative data as shown in Table 1 below:

Table 1. Guidelines for Converting Quantitative Data to Qualitative Data

Score Interval	Category
85,01% - 100%	Very Good
70% - 85%	Good
50,01% - 69,9%	Not Good
1% - 50%	Bad

Modifikasi Sa'dun (2013)

The determination of the percentage value in these criteria is obtained by the formula:

$$Percentage = \frac{Total\ Empirical\ Score}{Total\ Maximum\ Score} \times 100\% \quad (1)$$

The E-Modul Penyajian Data product is said to be valid if the validator's assessment is at least in the "good" category. The E-Modul Penyajian Data is said to be practical if the teacher's assessment, student assessment and observation sheet for the implementation of learning are at least in the "good" category.

To analyze the effectiveness of the e-Module, it is carried out by giving posters to students after using the e-Module for Data Presentation in the learning process. The E-Modul Penyajian Data is said to be effective if there is an increase in the average ability to understand mathematical concepts and a decrease in students' mathematical anxiety. E-modules are declared effective if they meet two criteria. First, there was an increase in the average score of understanding mathematical concepts, which was compared through descriptive statistics with a reference of the Kriteria Ketercapaian Tujuan Pembelajaran (KKTP) score of 70. Second, there was a decrease in the average score of students' math anxiety, which was analyzed based on the category of math anxiety. Anxiety categories are determined using a score interval modified from Sungkono et al. (2022). Scores of 26–50 were categorized as low anxiety, while 0–25 indicated very low anxiety.

Table 2. Categories Math Anxiety

Score Interval	Value	Category
$X > \bar{X}_i + 1 \times sb_i$	75 < x ≤ 100	Very High
$\bar{X}_i < X \leq \bar{X}_i + 1 \times sb_i$	50 < x ≤ 75	Tall
$sb_i < X \leq \bar{X}_i$	25 < x ≤ 50	Low
$X \leq sb_i$	0 < x ≤ 25	Very Low

Modifikasi Sungkono et.al (2022)

Information:

$\bar{X}_i$ = Rerata ideal

$\bar{X}_i$ = 1/2 (ideal maximum score + ideal minimum score)

sb_i = 1/4 (ideal maximum score – ideal minimum score)

X = Empirical score

The comparison of empirical scores with the intervals of these categories provides an idea of the decrease in anxiety levels after the use of e-modules. E-modules are declared effective if the learning results show an increase in concept understanding and a decrease in anxiety to a lower category.

In addition to assessing the effectiveness through the KKTP, the paired sample t-test was used in this study because the pretest and postes scores in this study were obtained from the same sample. This is in line with Nuryadi et al. (2017) which states that the paired t-test is one of the hypothesis testing methods where the data used in pairs (using the same sample to obtain pretest and postes scores). The paired t-test applies the test statistics:

$$t = \frac{\bar{d}}{\frac{s_d}{\sqrt{n}}} \quad (2)$$

Information:

t = t-value calculated

$\bar{d}$ = the average difference in pretest measurement to the poles

sd = standard deviation of the difference between the pretest measurement to the poles

n = Number of samples

The interpretation of this test can pay attention to the p-value. If the p-value obtained is less than the set real level of 0.05, then Hα_0 is rejected or the post-test value is better than the pre-test value. If the post-test score is better than the pre-test score, then the developed e-Modul Penyajian Data is effective in improving the ability to understand mathematical concepts and reduce mathematical anxiety.

Findings and Discussion

The development of the E-Modul Penyajian Data product oriented to students' ability to understand mathematical concepts and mathematical anxiety was developed using a 4D (Define, Design, Develepoment, Disseminate) development model. The following is an explanation of each stage of product development.

Define

The definition stage aims to analyze the initial needs in the development of the E-Modul Penyajian Data. These analyses include: End-End Analysis: Learning is still dominated by whiteboards and printed books, leading to a lack of interactivity as well as student boredom. Therefore, innovative

learning media such as e-Modules are needed. Student Analysis: Students have access to smartphones and the internet, but still have difficulty understanding mathematical concepts and have high levels of anxiety. Task & Concept Analysis: Learning outcomes and key concepts in data presentation are analyzed and designed in the form of concept maps to facilitate understanding. Formulation of Learning Objectives: The e-Module aims to improve the understanding of the concept of data presentation and reduce students' anxiety through the Problem Based Learning (PBL) approach. Product Specifications: The e-Module is developed in flip PDF format using the Flip PDF Corporate Edition with interactive features such as practice questions, multimedia materials, and online access to Student e-Worksheet.

Design

In this research, a discovery learning model supported by E-Worksheet based Student Worksheets was implemented with the aim of improving students' mathematical communication skills and self-efficacy. The research data shows that the data is normal and homogeneous, as can be seen in Table 1. The product developed is in the form of a flipbook-based E-Modul Penyajian Data using Flip PDF Corporate Edition. This E-Module is designed to support mathematics learning in data presentation materials by applying the Problem-Based Learning (PBL) model. The interactivity of the e-Module is strengthened through an interactive Wizer.me-based Student e-Worksheet, which allows students to work on assignments as well as discuss through the available discussion rooms. The application of PBL in this e-Module begins by orienting students to problems through reading the context of the problems presented. Furthermore, students are directed to study in groups by discussing the problem. In the investigation stage, students listen to video material, learn sample questions, collect information, and discuss both through Wizer.me and with teachers. After that, each group develops and presents the work by compiling the best answer and presenting it in front of the class. In the final stage, students analyze and evaluate the results of the work through joint conclusions based on the ongoing discussion process.

The development of this e-Module is focused on improving the ability to understand mathematical concepts as well as reducing students' mathematical anxiety. The Student e-Worksheet in the e-Module is compiled based on concept understanding indicators, such as the ability to restate concepts, identify examples and non-examples, and apply concepts in problem solving. These e-Modules are also designed to create a more enjoyable and less stressful learning experience. Students can learn the material through text and video, as well as access activity sheets and formative tests anytime and anywhere, so it is expected to help reduce math anxiety. Thus, the E-Modul Penyajian Data not only plays a role in improving understanding of concepts, but also supports a more positive learning atmosphere.

In addition to the e-Module, other supporting instruments are also prepared, namely teaching modules, pretest and post-test questions on concept comprehension skills, mathematics anxiety questionnaires, observation sheets on learning implementation, and practicality questionnaires for teachers and students.

Develpment

Creation of E-Modul Penyajian Datas

The development process of this E-Modul Penyajian Data is assisted by several platforms such as canva.com is used to design the E-Modul Penyajian Data, flipbuilder.com is used for the E-Modul Penyajian Data and wizer.me is used for the Student e-Worksheet feature in which there is also a space for discussion, YouTube.com as a learning video medium, and google form is used for mathematical anxiety questionnaires. This E-Modul Penyajian Data is designed using the Problem Based Learning (PBL) learning model with the Problem Based Learning (PBL) learning model.

The development process of this E-Modul Penyajian Data has a special mission, which aims to improve the ability to understand mathematical concepts and reduce students' mathematical anxiety. This

purpose is the characteristic or uniqueness of this e-Module so that it is different from other e-Modules. The design is made attractive with a suitable color combination.

Figure 1. Initial design (a) Cover; (b) Table of Contents; (c) How to Use; (d) Pancasila Student Profile; (f) Learning Outcomes and Objectives; (g) Statistical figures; (h) Learning Activities; (i) Bibliography

Product Validation

After developing the E-Modul Penyajian Data by paying attention to the two orientations for the development of the E-Modul Penyajian Data, then the e-Modul Penyajian Data is validated by the validator. Product validation aims to ensure the validity of the e-module, both in terms of material and appearance. The experts were selected from two lecturers who are experts in the field of mathematics education and experienced in teaching mathematics materials.

After all were validated, the researcher then revised all instruments based on comments and suggestions from both validators. Here are some inputs/suggestions from validators.

Table 3. Feedback/Suggestions from Validators

Validator Field	Feedback and Suggestions for Improvement
Material Expert	Writing Improvements
Media Expert	Video size reduced for easy access and some sentences that are not in accordance with EYD please be corrected

The validator provides an assessment with several improvements, after which the new improvements can be declared feasible or valid to use. Input from the subject matter expert validators is presented in Figure 2 below:

(A) (B) (C)

Figure 2.Appearance of the e-Module After Revision

In Figure 2(A), the material expert validator gives input to improve the writing. The sentence before the revision "Praise be to God SWT. for the abundance of His grace and bounty...", the upper word is deleted and the word bounty is changed to His bounty. Furthermore, there is writing that needs to be improved also in learning outcomes. The following are the results of the revision on learning outcomes. In Figure 2(B), the material expert validator gives input to improve the writing. The sentence before the revision "Students can formulate questions, collect, present and analyze data...", the typo of the word present is changed to present. Furthermore, there is writing that needs to be improved also in learning activities 2. The following are presented the results of the revision in learning activity 2. In Figure 2(C), the material expert validator gives input to improve the writing. The sentence before the revision "the number of students is 30 and the weight also varies, ranging from 40 to 44", the repeated word was removed.

After repairing, it can only be declared feasible or valid for use. The following are the results of validation by material experts and media experts.

Table 4. Validation Results by Material Experts and Media Experts

Instruments	Percentage	Information
Material Expert		
E-Modul Penyajian Data	83,16%	Good
Students' Mathematical Concept Comprehension Ability Test	84,62%	Good
Student Math Anxiety Questionnaire	84,44%	Good
Media Expert		
E-Modul Penyajian Data	80%	Good
Practicality Sheet by Teacher	84,44%	Good
Practicality Sheet by Students	84%	Good
Learning Implementation Observation Sheet	88,05%	Very Good

The assessment of the results of the validation of the instrument by material experts and media experts was declared "valid" and feasible to use.

Limited Trial

After the E-Modul Penyajian Data product is declared valid, a limited trial is then carried out for junior high school grade VII students to determine the readability of the E-Modul Penyajian Data media and the operation of use. The revised results after validation by material experts and media experts were tested on students through a limited trial.

At a time when the trial was limited in class, there were things that were found to be a revision of the E-Modul Penyajian Data. The finding is that the Student e-Worksheet in learning activity 2 cannot be accessed. So that the researcher re-inputs the Student e-Worksheet Link in the Flip PDF Corporate Edition after which it is republished and can be used again by students. Students also provide suggestions to improve the image quality of the E-Modul Penyajian Data. After a limited trial, revisions were made based on suggestions from students by republishing the E-Modul Penyajian Data using a higher resolution.

Field Trials

After completing the revision, the researcher then carried out field trials for the products that had been developed. The E-Modul Penyajian Data was tested in class VIIC in one of the schools in Sleman Regency which amounted to 30 people. In this trial, the researcher taught using the E-Modul Penyajian Data with the PBL learning model and the mathematics teacher acted as an observer.

The learning process was carried out in 5 meetings consisting of 1 pretest meeting, 3 learning process meetings and 1 postes meeting. In addition to giving posters, students were also given a practicality questionnaire to get practicality data.

The practicality of the E-Modul Penyajian Data is assessed through teacher response questionnaires, student response questionnaires, and learning implementation observation sheets. The results of the practicality questionnaire by teachers showed an average percentage of 91%, which is included in the very practical category. Students' assessments of e-modules obtained an average percentage of 81%, with a practical category. In addition, the implementation of learning observed during the three meetings reached an average of 89.49%, also in the very good category. Overall, the results of the questionnaire and observations showed that the E-Modul Penyajian Data met the practical criteria for use in mathematics learning.

The effectiveness aspect is used to determine the achievement of learning objectives. The effectiveness of the E-Modul Penyajian Data is seen from the increase in the ability to understand mathematical concepts and the decrease in students' mathematical anxiety before and after using the E-Modul Penyajian Data. The results were seen from an increase in the KKTP score of at least 70, an increase in the average ability to understand mathematical concepts and a decrease in students' mathematics anxiety before and after the implementation of the E-Modul Penyajian Data with the PBL learning model.

Based on data analysis, it was obtained that there was an increase in the average score of pretests and postes in students' mathematical concept comprehension ability, which was 37.95 to 75. There are 25 students out of 30 students who achieve KKTP in concept comprehension ability. Furthermore, there was a decrease in the average score of students' pretests and posttests of math anxiety, which was 59 to 45 which indicates that the average level of students' math anxiety decreased, there were 27 students out of 30 students who achieved an average anxiety score of ≤ 50.

In addition, hypothesis testing was also carried out to see from the increase in the score whether there was a significant difference between the average score of the pretest and posttest ability to understand mathematical concepts and students' mathematical anxiety before and after using the E-Modul Penyajian Data through a paired t-test using the R program. In the ability to understand mathematical concepts, a value of t=14.314 was obtained with the results of the test of t > t_tabel (14.314 > 1.699), so that there was a significant increase in the postes score. These findings show that the E-Modul Penyajian Data is effective in improving students' ability to understand mathematical concepts. In the mathematics anxiety variable, a value of t=-5.0101 was obtained with the results of the t< t_tabel test (-5.0101 < -1.699), so that there was a significant decrease in the students' post-math anxiety scores. Thus, the E-Modul Penyajian Data developed is effective in improving concept understanding while reducing students' math anxiety.

Based on the hypothesis test with the paired t-test, it was found that between the pretest and post-test scores there was a significant increase in the ability to understand mathematical concepts and a decrease in students' anxiety before and after using the E-Modul Penyajian Data. The use of the E-Modul Penyajian Data in the learning process is clearly seen in the differences in student behavior, students are more active in discussing in groups and solving problems given with their group friends, students also actively ask questions if there is something that has not been understood. The effectiveness of the E-Modul Penyajian Data is seen from the results of the test of mathematical concept comprehension ability and the students' mathematical anxiety questionnaire. It can be concluded that the E-Modul Penyajian Data is effectively used in the learning process.

Disseminate

The stage of product dissemination is a data presentation model. The products that have been developed must be disseminated and socialized to a wide audience from outside the scope of the development of e-modules for data presentation. However, at this stage the dissemination was not carried out in this study because this research uses the 4D Thigaarajan model where if it reaches the stage of dissemination it must be published and disseminated. Considering that this research was carried out by students with limitations, facilities, time and costs, this research only reached the development stage.

Conclusion

This study produced a E-Modul Penyajian Data developed using the 4D model, which meets the characteristics of a good e-module, namely self-instructional, self-contained, stand-alone, adaptive, and user-friendly. The e-module provides clear learning objectives, instructional materials and worked examples, learning videos, student worksheets, formative tests, assessment instruments, feedback, and

anxiety tests in each learning activity, enabling students to engage in independent learning. The validation results indicate that the e-module falls into the "good" category in terms of both material and media. The practicality test shows very good responses from teachers, good responses from students, and very good levels of learning implementation. In terms of effectiveness, the analysis demonstrates an improvement in students' conceptual understanding and a reduction in mathematics anxiety after using the e-module. Therefore, this PBL-based E-Modul Penyajian Data is proven to be valid, practical, and effective as a learning medium to support students' conceptual understanding and reduce mathematics anxiety.

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