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Development of STEM-based Descriptive Statistics Course Modules to Improve Mathematical Literacy

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Abstract: Mathematical literacy skills are very necessary so that students are able to face educational challenges in the cognitive aspect. One thing that has characteristics to answer the demands of 21st century learning is STEM. This study aims to develop a stem-based Descriptive Statistics course module using book creators to improve mathematics literacy skills with good quality that meets valid, practical, and effective. This research is development research using the Plomp model which consists of an initial investigation phase; design phase; realization/construction phase; test, evaluation, and revision phases; and implementation. The subject of this study is a student of the Mathematics Education Study Program at Universitas Tidar for the 2022/2023 academic year. The research instruments used in this research were validation sheets, questionnaires, and research instruments. This module is designed and developed based on the needs of students. After being developed this module was validated by two experts who are competent in their fields. The results of the module validity assessment based on experts are valid with an average of 74.5 with good categories. The practical results are based on student assessments which have a percentage of 56.52% with excellent criteria and 39.13% with good criteria. The statistical significance test of the module is based on test results with a classical average of 92.25 and the percentage of students whose scores are above KKM (≥ 75) is 86.93%. The data analysis results using the Wilcoxon test show that there is an influence of using the STEM learning model on mathematical literacy with a p-value lower than 0.05. The STEM learning model improves the mathematical literacy abilities in the medium category (N-Gain = 0.3889).Therefore, this lecture module is suitable to be used as one of the learning resources for the Descriptive Statistics and meets the quality aspects of validity, practicality, and effectiveness.

Keywords: module, descriptive statistics, book creator, mathematical literacy.

▪ INTRODUCTION

In the current 4.0 Industrial Revolution, everyone must possess 21st-century abilities or skills, including critical thinking and problem solving, creativity and innovation, communication, and collaboration (van Laar et al., 2017). The Industrial Revolution 4.0 era is a challenge for the world of education (Qondias et al., 2022). All educational institutions (especially universities) must be able to provide their students with these 21st-century skills to compete or survive with other nations. Also, skills in finding, managing, and conveying information are as important as skills in using information and technology. Cheng (2017) stated that 21st-century skills and literacy include basic skills that become educational provisions.

21st-century learning demands all human beings to master technology and information management skills, learn and innovate, have a career and global awareness, and have the character to compete healthily based on science and technology. Education is there to answer and solve these challenges. One approach that has characteristics to answer the demands of 21st-century learning is STEM (Science, Technology, Engineering, and Mathematics). STEM memainkan peran penting dalam mempersiapkan

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siswa dengan literasi ilmiah dan keterampilan berpikir kritis yang diperlukan untuk sukses di dunia yang berkembang pesat (Cheng, 2024) STEM learning is currently an alternative to science learning that can build a generation capable of facing the challenging 21st century (Hannover, 2017). Torlakson (2014) stated that the four aspects are a harmonious blend of problems that occur in the real world with problem-based learning. This approach can create a cohesive learning system and active learning. It is because all four aspects can work simultaneously to solve problems. STEM learning is one of the breakthroughs for education in Indonesia. It aims to develop and create science and technology-based economics. The STEM approach is how science is reflectively integrated with technology into techniques where all of these disciplines contain elements of mathematics as the parent of science (Yakman, 2012).

One of the cognitive abilities improved using STEM is literacy (Kemdikbud, 2018). Mathematical literacy refers to the knowledge, skills, behaviors, and attitudes that students need to apply mathematics in a variety of contexts (Singh, 2023). Mathematical literacy helps to understand the role or use of mathematics in daily life while using it to make the right decisions as a constructive, caring, and thinking citizen (OECD, 2013). Mahmud (2019) explained literacy is vital in all aspects of life, both at home and in society. Literacy skills mean the ability, confidence, and willingness to engage with quantitative or spatial information to make informed decisions in all daily aspects (Alberta, 2018).

Mathematical literacy is the knowledge and skill to use various kinds of numbers and symbols related to basic mathematics to solve practical problems in life, and then analyze the information displayed in various forms and interpret the results of the analysis to predict and make decisions (Kemdikbud, 2017). Ojose (2011) defines mathematical literacy as knowledge to know and apply basic mathematics in everyday life. According to Martin (2007), literacy is more than the ability to read, write, speak, and use language. Activity is very important in learning mathematics because it can help improve student achievement, this is in accordance with the opinion (House, 2006) which states that student mathematics achievement caused by internal factors (hard work or activity) is better than student achievement caused by external factors. In simple terms, mathematical literacy means the ability to apply number concepts and arithmetic operations skills in everyday life (such as at home, work, and participation in community life). It also means interpreting quantitative information around us. Someone's mathematical literacy ability can be observed from his skills in formulating, applying, and interpreting mathematics in different contexts. The contexts include including reasoning mathematically and using concepts, procedures, and facts to describe, explain or predict certain phenomena or events (OECD, 2013).

There was an initial study on mathematics education students at a university in Magelang, Central Java, Indonesia. The results showed that the mathematics literacy of third-semester students in 2020 was still low. Out of 30 students, only five could analyze arguments well in solving descriptive statistics problems. None of the students were able to conclude correctly. This means that there were no students who could achieve the indicators of mathematical literacy. This problem may be due to several factors. Based on the results of interviews with them, this difficulty was because, in descriptive statistics learning, they were not used to discussing mathematical literacy. Also, it is closely related to the teaching materials. The results of preliminary observations show that 83.4% of

students use reference books and articles from the internet. Appropriate modules as the teaching materials do not yet exist. Learning using modules can develop students' independent abilities. The learning modules can train their independence with the components in them. The modules are made systematically and interestingly. They include materials, methods, and evaluations (Basilotta, 2017).

Based on the descriptions above, the researchers are encouraged to develop STEM-based descriptive statistics course modules using book creators to improve the students' mathematical literacy. The specifications of the modules to be developed are: 1) the modules are in the form of e-modules; 2) the modules contain descriptive statistics material, and; 3) the modules are presented according to STEM learning components. By developing these modules, the learning process can run more meaningfully. Also, the use of the modules can equip the students with STEM-based learning and mathematical literacy.

▪ METHOD

Participants

The population in this study were students from the Mathematics Education Study Program at Universitas Tidar. The sample used was students from Mathematics Education Study Program at Universitas Tidar, semester III in the 2022/2023 academic year, totaling 23 students. The sampling technique used was random sampling.

Research Design and Procedures

This is a research and development (R&D) study with the PLOMP development model. The Plomp model consists of an initial investigative phase; design phase; realization/construction phase; test, evaluation, and revision phases; and implementation. The research procedures used in this research refer to the stages of the Plomp model, namely (1) the initial investigative phase, at this stage an analysis of the curriculum and descriptive statistics reference books, STEM-based learning steps, use of book creators, and indicators of mathematical literacy abilities are carried out; (2) design phase, at this stage a STEM-based module design is prepared for the descriptive statistics course using a book creator. Apart from that, research instruments were also prepared which included module assessment instruments and mathematical literacy test instruments; (3) realization/construction, at this stage the module is validated by material experts and media experts and revised according to the input provided so that a suitable and valid module is obtained; (4) test, evaluation, and revision phases, at this stage an initial trial is carried out on students who have taken the descriptive statistics course as a reference for carrying out revisions again to improve the module; (5) implementation, at this stage a field test is carried out using the module that has been developed to determine the effectiveness of the module being developed.

Instruments

The data are collected using validation sheets, questionnaires, and test instruments. The data collection instrument is for assessing validity, practicality, and effectiveness. The validation sheet is used to measure the level of validity of the modules and test instruments developed. The questionnaire used in this research is a questionnaire for validators and student assessments regarding the use of the module. The test instrument was used to obtain data on the effectiveness of the modules developed by researchers to

improve mathematical literacy. The indicators of mathematical literacy are shown in the following table.

Table 1. Mathematical literacy ability indicator

Mathematical Literacy Process	Mathematical Literacy Ability Indicator
Formulating	Formulate problems mathematically (*mathematising*) Describe the problem encountered *(communication)*
Employing	Designing strategies to find mathematical solutions *(divising stategies for solving problem, mathematics tool)* Using mathematical symbols and operations *(Using Symbolic, Formal and Technical Language and Operation)* Using mathematical concepts, facts, procedures, and reasoning *(reasoning and argument)*
Interpreting	Interpret, the results of a problem-solving process *(representation)*

Data Analysis

Data analysis techniques consist of validity analysis, practicality analysis, and effectiveness analysis of STEM-based descriptive statistics modules. The explanation of the data analysis is as follows.

Validity Analysis

The data validation is based on a questionnaire related to the feasibility of the content/material of the Descriptive Statistics course, the presentation using STEM-based modules, and the language. Besides the modules, there is also a validation for the test instrument. Next, the average scores of the results of the validator's assessment are converted to check if the modules and test instruments are valid and feasible or not. In the following table, there is a recap of the criteria for the ideal minimum score, the ideal maximum score, the average ideal score, and the standard deviation of the ideal score from the modules and test instrument.

Table 2. Recap of the criteria for the minimum ideal score, the maximal ideal score, the average ideal score, and the standard deviation of the ideal score for the practicality of students' assessment

Validated Item	Number of Items	Min. Ideal Score	Max. Ideal Score	X	Sbi
Modules	20	20	100	60	13.3

The modules are declared valid when the validator provides an assessment with minimum criteria suitable for use with revisions and has an average score with a minimum criterion of good for the module. The validity of the module is considered "very good" if the score is more than 83.94. A module is considered "good" if the score is between 67.98 and 83.94. A module is considered "adequate" if the score is between 52.02 and 67.98. A module is considered "poor" if the score is between 36.06 and 52.02. A module is considered "bad" if the score is less than 36.06.

Practicality Analysis

Practicality analysis aims to determine whether the modules are practical or not.

The student assessment questionnaire on the modules contains a scale of five. This assessment is carried out at the end of the Descriptive Statistics course learning activity. The following table shows the ideal minimum score, ideal maximum score, average ideal score, and the standard deviation of the ideal score of the student assessment instrument.

Table 3. Recap of the criteria for the minimum ideal score, the maximal ideal score, the average ideal score, and the standard deviation of the ideal score for the practicality of students' assessment

Validated Item	Number of Items	Min. Ideal Score	Max. Ideal Score	X	Sbi
Students' Evaluation Instrument	14	14	56	35	7

Each student's average score is converted into a statement to determine the practicality assessment. The practicality of the module is considered "very good" if the score is more than 47.6. A module is considered "good" if the score is between 39.2 and 47.6. A module is considered "adequate" if the score is between 30.8 and 39.2. A module is considered "poor" if the score is between 22.4 and 30.8. A module is considered "bad" if the score is less than 22.4. In this research, the development of the Descriptive Statistics course modules is stated as practical when 75% of students have at least good criteria.

Effectiveness Analysis

The effectiveness level is set from the results of the students' pre test and post-test on the results of the mathematical literacy ability test. The instrument used to measure literacy skills is in the form of test questions consisting of 4 questions each for pre-test and 4 post-test questions. Each question makes all three indicators of mathematical literacy. Instrument data analysis through test question validity, reliability, differentiation, and difficulty level.

Final data analysis was carried out using the results of the pretest and posttest after the study. Before analyzing the final data, it is necessary to carry out a prerequisite test, namely the normality and homogeneity test, which can then be analyzed using the Paired Sample T-Test (meets the prerequisite test for normality). If it does not meet the normality, it can be done with a non-parametric test, namely the Wilcoxon test. In addition, the N-Gain test was used to determine the improvement of the given treatment.

In addition, an N-Gain test was carried out to determine the improvement of the ability to treat. The results of the N-Gain calculation are then categorized based on the following Table 4.

Table 4. N-gain category

N-Gain Value	Category
$g \geq 0.7$	high
$0.3 \leq g < 0.7$	medium
$g < 0.3$	low

▪ RESULT AND DISSCUSSION

This is development research using the Plomp model consisting of a preliminary investigation phase, design phase, realization/construction phase, test, evaluation and revision phase, and implementation (implementation).

Preliminary Investigation

This stage includes analyzing needs or problems. It also involves conducting preliminary studies and collecting relevant data. In the analysis stage, instructional problems are clarified, instructional goals and objectives are determined, and the environment, knowledge and skills possessed by students are identified (Patel et al., 2018). Key components of this process are curriculum analysis and referencing descriptive statistics books, which provide foundational knowledge for understanding data trends and patterns. Additionally, resources on the syntax and steps of STEM-based learning, the use of book creators, and indicators of mathematical literacy skills are essential. These elements collectively form the basis for a comprehensive educational framework aimed at addressing current educational gaps and enhancing students' analytical abilities.

However, a significant issue identified is the absence of a descriptive statistics course module that incorporates STEM elements. This gap highlights a missed opportunity to integrate interdisciplinary approaches that can enrich students' learning experiences. Furthermore, there is a lack of books specifically designed to help students improve their mathematical literacy skills. Addressing these deficiencies is crucial, as enhancing mathematical literacy is vital for students to develop critical thinking and problem-solving abilities in various real-world contexts.

Design

This stage aims to design a solution to the problems identified in Phase 1. In this step, the researchers compile a STEM-based module design (draft) using a descriptive statistics course book creator. STEM is an approach that integrates the fields of science, technology, engineering, and mathematics into a unified whole in the process (Bybee, 2013). Besides the module design, the researchers also prepare instruments for both module assessment instruments and mathematical literacy test instruments in the descriptive statistics course. The module assessment instruments are in the form of module validation instruments and questionnaire instruments for the students.

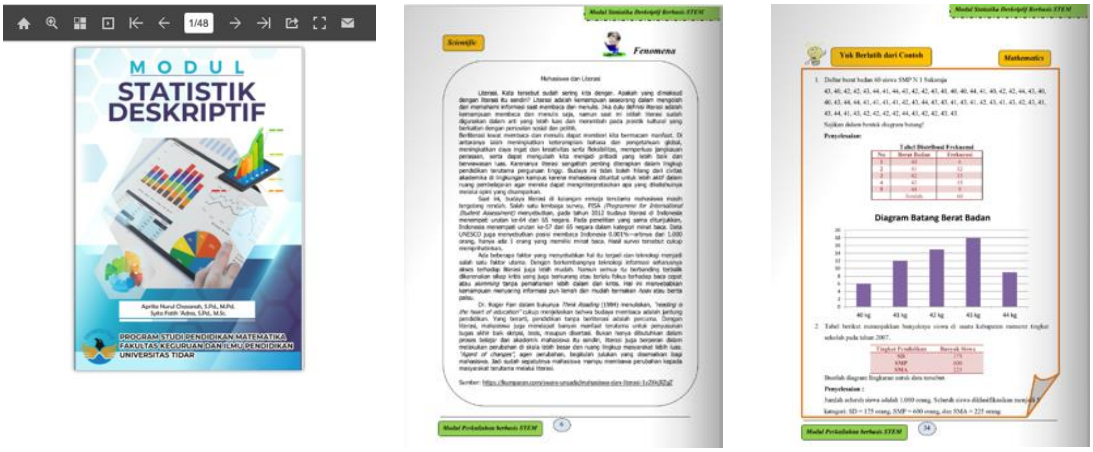

Figure 1. Display of STEM-based descriptive statistics module

Realization/Construction Stage

This stage includes module validation and revision. The modules that have been compiled are validated by two validators. In general, the validation results show the modules are feasible or valid to be used with some necessary revisions with the following score. This is in accordance with research results Nindiasari (2022), which state that numeracy-based e-modules fulfill validity aspects. The validation process ensures that the modules meet educational standards and effectively address the intended learning outcomes.

Table 5. Recapitulation of module validation results

Validated Item	Validator I	Validator II	Average	Category
Module	71	78	74.5	Good

The validators suggest some revisions in terms of the quality of the modules, consistency of the use of letters and display icons, minimum components that must be met, improvement of the images, practice questions, and additional STEM elements and mathematical literacy. The next step is to revise the modules according to the suggestions and input from the validators. After the revision is complete, the modules are implemented in the class to be studied.

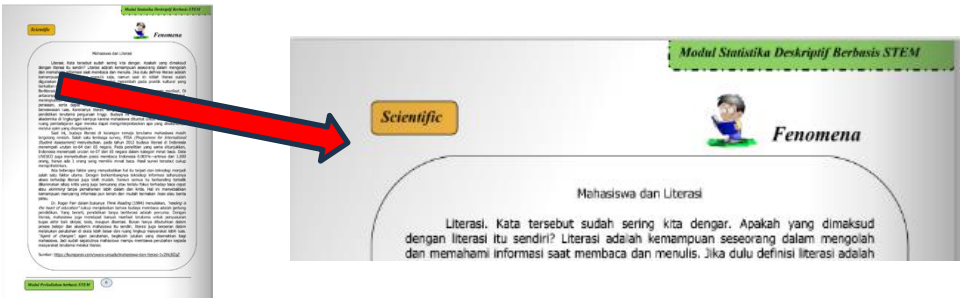

Figure 2. Examples of scientific elements in modules

Testing, Evaluation, and Revision

The initial field trial is through testing the modules on third-semester students who have taken a descriptive statistics course. This stage is an experimental activity of using the product on a limited basis (conducting an initial field test of a limited product design to check practicality). This limited field test is conducted on 23 students of the Mathematics Education Study Program. 22 students give an assessment of the descriptive statistics course module on the minimum criteria (95.65%). Therefore, the modules are stated as practical to use. This is in accordance with the opinion of Sari et al (2023) who stated that worksheets developed to improve mathematical literacy skills meet practical criteria. Based on the results of expert validation and experiment in limited trials, there are inputs for improvements. This stage is to revise the product from the testing results on a limited basis.

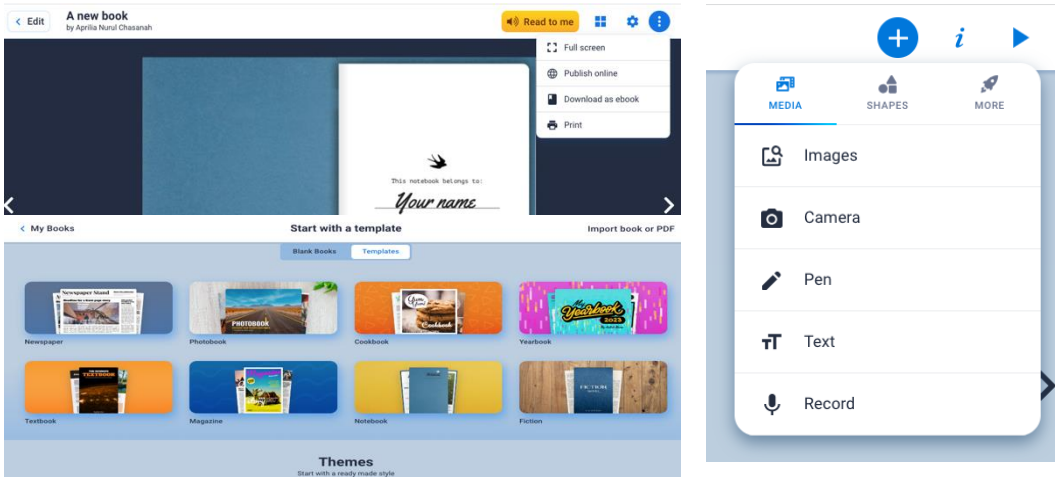

Figure 3. Utilization of book creator features to support the presentation of descriptive statistical material

Implementation Stage

After successful product testing, the descriptive statistics course modules can be tested in a wider scope. The modules are distributed to the third-semester students of the Mathematics Education Study Program to get the aspect of effectiveness. At the trial stage, the effectiveness test is by giving post-test descriptive statistics questions. The following table presents the results of the effectiveness test.

Table 6. Recapitulation of students' assessment results on e-modules

Score	Number of Students	Percentage
100	6	15%
95	11	27.5%
90	10	25%
85	8	20%
80	3	7.5%
75	1	2.5%
70	1	2.5%

The modules are effective if the students' percentage who achieve the Minimum Completeness Criteria (KKM; 75) is more than or equal to 80% (Kemp, Marrison, & Ross, 1994: 289). The table shows that 20 of 23 students can obtain a minimum score of 75 or 86.93% classically. Therefore, the modules are said to be effective to use. This is in accordance with research by Widyastuti & Wijaya (2020) which states that developing learning modules can help improve students' mathematical literacy.

The data show that the Descriptive Statistics modules are appropriate teaching materials in learning activities for the lecturers and third-semester students of the Mathematics Education Study Program.

The wilcoxon test in the pretest and posttest values produces p−value=0.000, because p−value<0.05 can be concluded that there is a difference in mathematical literacy ability before and after treatment.

Table 7. Normality test of mathematical literacy ability

Treatment	$L_{calculate}$	L_{tabel}	Conclusion
Pretest	0.1961	0.1419	Abnormal distribution
Posttest	0.0733	0.1419	Normally distributed

Based on the table, it can be seen that the normality test on the posttest value produces ,L-calculate.=0.1961 and ,L-table.=0.1419, because ,L-calculus.>,L-table. then it can be concluded that the posttest values are abnormally distributed. Then, the posttest value produces ,L-calculate.=0.0733 and ,L-table.=0.1419, because ,L-calculate.<,L-table. then it can be concluded that the posttest values are normally distributed.

Table 8. Wilcoxon test of mathematical literacy ability

Treatment	$P - value$	Conclusion
Pretest dan Posttest	0.000	There is a difference

Based on the table, it can be seen that the wilcoxon test in the pretest and posttest values produces p−value=0.000, because p−value<0.05 can be concluded that there is a difference in mathematical literacy ability before and after treatment. In addition, an N-Gain test was carried out to determine the improvement of the ability to treat. The results of the N-Gain calculation are then categorized based on the following Table 9.

Table 9. N-Gain category

N-Gain Value	Category
$g \geq 0.7$	high
$0.3 \leq g < 0.7$	medium
$g < 0.3$	low

Furthermore, students' mathematical literacy skills can be seen from the N-gain score. Based on the N-gain value of mateamtika literacy ability, which is 0.3889. Thus, there is an increase in students' mathematical literacy taught through the STEM learning model in the medium category of improvement. This is in line with the research of Kelana et al. (2020) which stated that the STEM learning model can have an influence and improve students' abilities, especially on mathematical literacy skills.

▪ CONCLUSION

Based on the results of the research conducted, it was found that the validity aspect of the modules is based on the assessment of the two validators with an average of 74.5 with good criteria. It can be concluded that the results of the development of the descriptive statistics course modules are valid. The practical aspect of the modules is based on the student's assessment with a percentage of 56.52% with very good criteria and 39.13% with good criteria. The results of the development of the practical descriptive statistics modules are effective. The effectiveness aspect of the modules is based on classical learning outcomes with the percentage of students with a minimum score of 75 (86.93%). The implementation of the results of developing the descriptive statistics course modules is effective Therefore, it can be concluded that the modules are feasible

as a source of learning and teaching materials that meet the valid, practical, and effective qualities.

It is hoped that further research can be carried out in relation to other descriptive statistical material, for example, measures of deviation, dispersion, variance, moments, skewness, and kurtosis. In addition, it is hoped that future research can use other development models and experimental designs to obtain better results.

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