DEVELOPMENT OF A CONTEXTUAL TEACHING AND LEARNING-BASED TEACHING MODULE ON STATISTICS TO FACILITATE STUDENTS' MATHEMATICAL COMMUNICATION SKILLS

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ABSTRACT This study was motivated by the issue of students' low performance in mathematical communication skills. The purpose of this development research was to produce a teaching module based on the Contextual Teaching and Learning (CTL) approach for the topic of statistics, aimed at facilitating the mathematical communication skills of seventh-grade students in junior high school. The research was conducted at SMPN 17 Pekanbaru and employed the ADDIE development model, which includes the stages of Analysis, Design, Development, Implementation, and Evaluation. Validation of the teaching module was conducted by three expert validators, followed by revisions based on their suggestions and feedback. A one-on-one trial with three students was then carried out to evaluate the readability of the student worksheet within the module. After being declared valid, the module was tested on a small group of six students and a large group of 33 students to assess its practicality. The results showed that the average validation score was 90%, which falls into the "very valid" category. Furthermore, the average student response score was 91%, indicating a "very practical" category. These findings suggest that the developed teaching module is both valid and practical, and can be effectively used by teachers in the mathematics learning process.

Keywords: Contextual Teaching and Learning, teaching module, mathematical communication skills, statistics, development research

ABSTRAK Penelitian ini dilatarbelakangi oleh rendahnya kemampuan komunikasi matematis peserta didik. Tujuan dari penelitian pengembangan ini adalah untuk menghasilkan modul ajar berbasis pendekatan Contextual Teaching and Learning (CTL) pada topik statistika yang dapat memfasilitasi kemampuan komunikasi matematis siswa kelas VII SMP. Penelitian ini dilaksanakan di SMPN 17 Pekanbaru dengan menggunakan model pengembangan ADDIE, yang meliputi tahapan Analisis, Desain, Pengembangan, Implementasi, dan Evaluasi. Validasi modul ajar dilakukan oleh tiga validator ahli dan diperbaiki berdasarkan masukan serta saran yang diberikan. Selanjutnya dilakukan uji coba terbatas terhadap tiga peserta didik untuk menguji keterbacaan lembar kerja dalam modul. Setelah dinyatakan valid, modul diuji coba pada kelompok kecil (6 peserta didik) dan

kelompok besar (33 peserta didik) untuk mengukur kepraktisan penggunaannya. Hasil penelitian menunjukkan bahwa rata-rata skor validasi sebesar 90% (kategori sangat valid) dan rata-rata hasil angket respon siswa sebesar 91% (kategori sangat praktis). Dengan demikian, modul ajar yang dikembangkan dinyatakan valid dan praktis untuk digunakan oleh guru dalam proses pembelajaran matematika.

Kata-kata kunci: CTL, modul ajar, kemampuan komunikasi matematis, statistika, penelitian pengembangan

INTRODUCTION

Mathematical communication skills are essential for students, as they play a critical role in helping learners understand mathematical problems, express ideas clearly, and solve problems through critical, logical, creative, and independent thinking (Bernard, 2015). According to NCTM (2015), mathematical communication refers to students' ability to express mathematical ideas clearly through writing, speaking, diagrams, tables, graphs, or mathematical symbols. This ability is fundamental not only for enhancing conceptual understanding but also for fostering collaboration in problem-solving.

Cooke and Buchholz (2018) emphasize that mathematical communication significantly contributes to the development of higher-order thinking skills, such as analysis and evaluation, by enabling students to articulate their ideas clearly and engage effectively in collaborative problem-solving. Ferrara et al. (2017) further explain that effective mathematical communication allows students to connect mathematical representations with real-world phenomena, thereby deepening their understanding of mathematical concepts in a meaningful way. Similarly, Pierson and Berry (2019) argue that students with strong mathematical communication skills are more capable of interpreting various forms of representation, such as graphs and tables, and analyzing data more effectively—an essential skill in developing data literacy in today's digital era. These perspectives affirm that effective mathematical communication not only strengthens students' understanding of concepts but also facilitates the development of higher-order thinking and data literacy needed in the modern world.

Chazan et al. (2021) highlight that the ability to communicate mathematical ideas both verbally and in writing supports students in cultivating logical, systematic, and coherent thinking. Such skills are also crucial in preparing students to adapt to the demands of 21st-century learning. Despite its importance, several studies have shown that students' mathematical communication skills remain low. Research by Yuliani and Vioskha (2022) found that many students still struggle to represent mathematical problems through tables or graphs, to describe mathematical models, and to comprehend real-life contextual problems. In a similar vein, Alawiyah, Andriani, and Fitraini (2019) found that students faced difficulties in expressing

mathematical situations using diagrams or algebra, in explaining mathematical models, and in constructing questions from given scenarios.

These issues underscore the urgent need for effective instructional strategies that can improve students' mathematical communication abilities. One potential solution is well-planned instruction that aligns with students' needs. As emphasized by Noviarni (2016), successful learning is highly dependent on effective planning. Within the framework of the Merdeka Curriculum, teaching modules serve as essential tools in designing structured learning experiences. Teaching modules developed using a contextual approach, such as Contextual Teaching and Learning (CTL), offer a promising alternative. The CTL approach encourages students to connect the content being learned with real-life contexts, thereby improving both relevance and conceptual understanding (Riyanto, 2014). Therefore, this study aims to develop a CTL-based teaching module on the topic of statistics that facilitates students' mathematical communication skills and meets the criteria of validity and practicality.

METHODS

This study is a type of research and development (R&D) that adopts the ADDIE development model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation. At the analysis stage, a needs assessment was carried out, including curriculum analysis and an analysis of students' characteristics. During the design phase, the teaching media and formats were selected, the teaching module was drafted, and both the validation sheet and student response questionnaire were prepared. In the development stage, the initial draft of the teaching module was completed and submitted for validation by three expert validators. The validation results were then analyzed using the formula proposed by Riduwan and Akdon (2015):

$$\text{Validity Percentage} = N = \left(\frac{\sum \text{total score from validators}}{\sum (\text{maximum questionnaire score} \times \text{number of validators})} \right) \times 100\%$$

The categorization of the validity scores is presented in Table 1:

Table 1. Validity Criteria for the Teaching Instrument

Category	Score Range
Very Valid	80% < N ≤ 100%
Valid	60% < N ≤ 80%
Fairly Valid	40% < N ≤ 60%
Less Valid	20% < N ≤ 40%
Not Valid	0% ≤ N ≤ 20%

Once the module was declared valid, a one-on-one trial was conducted with three students to examine the readability of the Student Worksheet (LKPD) included in the module. This was followed by the implementation stage, which involved two phases of trials: a small-group trial involving six seventh-grade students and a large-group trial involving one full class of 33 seventh-grade students. These trials aimed to evaluate the practicality of the module based on the students' responses to the post-trial questionnaire.

The student response data were analyzed using the formula below (Riduwan & Akdon, 2015):

$$\text{Practicality Percentage} = N = \left(\frac{\sum \text{total score from students}}{\sum (\text{maximum questionnaire score} \times \text{number of students})} \right) \times 100\%$$

The criteria used to interpret the practicality score are provided in Table 2:

Table 2. Practicality Criteria for the Teaching Module

Category	Score Range
Very Practical	80% < N ≤ 100%
Practical	60% < N ≤ 80%
Fairly Practical	40% < N ≤ 60%
Less Practical	20% < N ≤ 40%
Not Practical	0% ≤ N ≤ 20%

Based on the analysis of the student response questionnaire during the small-group trial, the teaching module was categorized as practical. Additionally, evaluation was carried out at the end of each ADDIE phase—Analysis, Design, Development, and Implementation—to ensure that each phase met its objectives and informed the next phase of the development process.

FINDING AND DISCUSSION

The research findings were obtained through the stages of the ADDIE development model. At the analysis stage, a needs analysis, curriculum analysis, and student characteristics analysis were conducted. The results of the needs analysis, which were based on literature reviews, indicated that seventh-grade students still demonstrated low levels of mathematical communication skills. Several previous studies have confirmed this condition (Aulia et al., 2018; Madio, 2016; Pratiwi, 2015; Ikhsan et al., 2021). These low levels were caused by several factors, including students' inability to describe reasoning in response to reading texts, explain their problem-solving processes using mathematical ideas, connect and express situations

through mathematical thinking, and represent everyday events using appropriate mathematical language and symbols.

In terms of teaching materials, although the Merdeka Curriculum requires teachers to develop teaching modules that include structured learning plans and attachments, many teachers still lack sufficient knowledge and experience in designing such modules. Therefore, it is necessary to develop teaching modules that align with the Merdeka Curriculum and are designed to facilitate students' mathematical communication skills.

The development of the teaching module also considered an analysis of student characteristics. Generally, students aged 14 to 16 have developed the ability to think abstractly, logically, and mathematically. This aligns with the opinion of Nurhidayah (2018), supported by Piaget's theory, which states that junior high school students are capable of using formal operational thinking to solve problems.

Curriculum analysis was also conducted by referring to the Regulation of the Head of BSKAP No. 33 of 2022 regarding learning outcomes in Phase D, particularly in the domain of data analysis and probability, which is part of the statistics topic. Two core learning outcomes were used as the basis: (1) students are able to formulate questions, collect, present, and analyze data to answer those questions, and (2) students are able to use bar charts and pie charts to present and interpret data. These learning outcomes were used to derive specific learning objectives, which are shown in Table 3.

Table 3. Analysis of Learning Objectives

Learning Objective	Sub-Topic	Hours
Students can formulate questions from a news event or specific situation		
Students can collect data from a news event or specific situation		
Students can process data from a news event or specific situation	Data Investigation	2
Students can draw conclusions based on data from a news event or specific situation		
Students can identify the types of data in the given context		
Students can present data in the form of bar charts		
Students can interpret and conclude data from bar charts	Bar Charts	2
Students can present data in the form of line graphs	Line Graphs	2

Learning Objective	Sub-Topic	Hours
Students can interpret and conclude data from line graphs		
Students can present data in the form of pie charts	Pie Charts	2
Students can interpret and conclude data from pie charts		

Following this, a draft of the teaching module was designed, along with the preparation of validation sheets and student response questionnaires. The validation process covered not only the lesson plan but also the student worksheet and assessment tools. The validation sheet for the teaching module was developed based on content validity and construct validity, which included indicators such as the completeness of module components and the alignment of content with curriculum objectives. The validation sheet for the student worksheet included aspects of face validity, content validity, and construct validity. The validation sheet for assessments included content and construct validity as well.

The student response questionnaire was designed to measure three aspects: the visual appearance of the student worksheet, the quality of the content/material, and the ease of use (Ramdani, 2014). The medium chosen for development was print-based, supported by Microsoft Office Word 2019, in A4 paper format. The format of the module followed the structure required by the Merdeka Curriculum, consisting of general information, core components, and appendices.

The initial design of the teaching module is shown in Figure 1.

Figure 1. Teaching Module Design

The validation phase during the development stage was carried out after the module draft was completed. Validation was conducted by three experts: two mathematics education lecturers and one mathematics teacher with a master's degree. The results of their evaluations are presented in Table 4.

Table 4. Validation Results of the Teaching Module

Aspect	Indicator	Average	Category
Content	Completeness of general information components according to the teaching module guide	100%	Very Valid
	Completeness of identity components based on module guidelines	100%	Very Valid
	Relevance of general information	86%	Very Valid
	Completeness of core components based on module guidelines	100%	Very Valid
	Appropriateness of core learning activities	84%	Very Valid
	Completeness of learning activities	100%	Very Valid
	Completeness of introductory activities based on the Merdeka Curriculum	100%	Very Valid
	Completeness of core activities implementing Problem-Based Learning	100%	Very Valid
	Completeness of closing activities based on the Merdeka Curriculum	100%	Very Valid
	Completeness of appendix components according to the module guidelines	100%	Very Valid
Construct	Alignment of core activities with the Problem-Based Learning model	81%	Very Valid
	Core activities facilitating indicators of mathematical communication skills	86%	Very Valid
	Learning model aligned with mathematical communication skills	83%	Very Valid
	Application of Contextual Teaching and Learning approach in learning activities	84%	Very Valid
	Learning approach facilitating mathematical communication skills	75%	Valid
Overall Average		**92%**	**Very Valid**

Based on the validation results from the expert validators, the average validation score for the teaching module was 92%, which falls under the very valid category. This indicates that the developed module met the criteria for both content and construct validity.

Additionally, the module includes a student worksheet and assessment instruments in the appendix section. These components were also subject to validation. The results of the validation for the student worksheet and assessment tools are presented in Tables 5 and 6.

Table 5. Validation Results of the Student Worksheet

Aspect	Average Score	Category
Face Validity	98%	Very Valid
Content Validity	87%	Very Valid
Construct Validity	84%	Very Valid
Overall Average	90%	Very Valid

Based on the analysis of the validation results, the student worksheet achieved an average score of 90%, which is categorized as very valid. This means that the components and content of the worksheet were in accordance with the intended objectives and effectively support students' mathematical communication skills.

Table 6. Validation Results of the Assessment Instrument

Aspect	Average Score	Category
Content Validity	86%	Very Valid
Construct Validity	96%	Very Valid
Language Validity	97%	Very Valid
Overall Average	93%	Very Valid

The assessment instrument validation yielded an average score of 93%, also categorized as very valid, indicating that the assessment was well-aligned with the learning objectives and effectively designed to support the development of mathematical communication skills.

Following the validation stage, a one-on-one trial was conducted to evaluate the readability and practicality of the student worksheet, as well as to identify any difficulties students encountered while completing the tasks. After students completed Student Worksheets 1 through 4, it was concluded that some of the language used in the items was difficult to understand or lacked clarity. Revisions were made accordingly, using simpler and more student-friendly language suitable

for junior high school learners. Aside from these issues, no major problems were encountered during the trial.

At the implementation stage, a small-group trial was conducted involving six students from SMPN 17 Pekanbaru, comprising two students each from low, medium, and high ability levels. Each student worksheet was completed within 45 minutes. While working through the worksheets, students generally understood the tasks but often sought confirmation from the researcher to ensure they were interpreting the questions correctly. After completing each worksheet, students were asked to fill out a response questionnaire, with the results shown in Table 7.

Table 7. Student Response Questionnaire – Small Group Trial

Aspect	Average Score	Category
Student Worksheet Appearance	93%	Very Practical
Material Presentation	90%	Very Practical
Ease of Use	91%	Very Practical
Overall Average	91%	Very Practical

The small-group trial showed that the student worksheet reached an average score of 91%, placing it in the very practical category.

Next, a large-group trial was conducted involving one full class of students from SMPN 17 Pekanbaru with mixed academic abilities. Students were divided into eight groups, each consisting of four members. The duration for each worksheet remained at 45 minutes. Students were first briefed on how to complete the worksheets, after which they filled out their identification and worked collaboratively in their groups. The worksheets were designed using the Problem-Based Learning (PBL) model, requiring students to discuss and present their group findings to the class. During the group work, students frequently asked for clarification to confirm whether their understanding of the questions was correct. After completing the tasks, they also filled out a response questionnaire. The results are shown in Table 8.

Table 8. Student Response Questionnaire – Large Group Trial

Aspect	Average Score	Category
Student Worksheet Appearance	92%	Very Practical
Material Presentation	88%	Very Practical
Ease of Use	90%	Very Practical
Overall Average	90%	Very Practical

The results of the large-group trial confirmed the practicality of the teaching module, with an average overall score of 90%, also categorized as very practical.

The evaluation phase was carried out after the completion of each stage in the ADDIE model. As is standard in the ADDIE framework, evaluation was conducted iteratively after each of the four stages: Analysis, Design, Development, and Implementation. The evaluation cycle followed the sequence: Analysis → Evaluation → Design → Evaluation → Development → Evaluation → Implementation → Evaluation.

The final product of this research is a teaching module based on the Contextual Teaching and Learning (CTL) approach, focused on the topic of statistics for seventh-grade students. After undergoing expert validation (with an average score of 91%, categorized as very valid) and product testing through small- and large-group trials (with an average practicality score of 90%, categorized as very practical), the module was deemed feasible for use in the classroom to support students' mathematical communication skills.

This research aligns with findings from several related studies. Mardiah et al. (2024), for instance, developed a PBL-based mathematics teaching module on the topic of ratio to facilitate students' mathematical problem-solving skills. Their study resulted in a valid and practical module, similar in purpose and outcome to the present study. Inspired by this, the current research incorporates the PBL model within a CTL framework, creating a continuous and integrated instructional experience between approach (CTL) and model (PBL). Another relevant study by Restiani et al. (2024) focused on the development of a CTL-based student worksheet aimed at enhancing students' mathematical critical thinking skills at the junior high school level. While their study focused solely on the worksheet, the current study extends that work by developing a full teaching module aligned with the Merdeka Curriculum, using the same CTL approach and specifically targeting seventh-grade students on the topic of statistics.

CONCLUSIONS AND RECOMMENDATIONS

This development research produced a teaching module based on the Contextual Teaching and Learning (CTL) approach for the topic of statistics, aimed at facilitating the mathematical communication skills of seventh-grade junior high school students. The module was developed following the ADDIE model and underwent a validation process by expert reviewers. The validation results showed an average score of 91%, which falls under the very valid category. Furthermore, small-group and large-group trials were conducted with students, resulting in an average practicality score of 90%, categorized as very practical.

These results indicate that the developed teaching module meets the criteria for both validity and practicality, making it suitable for classroom use, particularly to support students in developing mathematical communication skills. Future research

is encouraged to develop similar modules for other topics and educational levels, to further enrich the availability of quality instructional materials aligned with the Merdeka Curriculum.

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