Journal Evaluation in Education (JEE)
Vol. 6, No. 1, January 2025, pp. 55~65
ISSN: 2716-4160, DOI: 10.37251/jee.v6i1.1321

Development of Statistical Teaching Materials using Statcal to Enhance Students' Statistical Literacy and Self-Efficacy

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Article Info

Article history:

Received Oct 17, 2024
Revised Nov 28, 2024
Accepted Dec 28, 2024
OnlineFirst Jan 04, 2025

Keywords:

Inferential Statistics
Self-efficacy
Statcal
Statistical Literacy
Teaching Materials

ABSTRACT

Purpose of the study: This study addresses the challenges of limited teaching materials and the need for innovative tools to enhance students' statistical literacy and self-efficacy by developing inferential statistics teaching materials integrated with Statcal software. The primary aim is to create and evaluate the effectiveness of these materials in improving students' skills and confidence in statistical learning.

Methodology: The research employed a qualitative approach and involved collaboration with two material expert lecturers, one statistical program expert lecturer, and one student. The development process followed four stages: definition, design, development, and dissemination, ensuring a comprehensive framework for creating effective teaching resources

Main Findings: Validation results showed the materials were valid with a score of 4.21, practical with an 83.72% score, and effective with an 82.4% score, all in the good category. Additionally, the teaching materials significantly improved students' statistical literacy (72.78%) and self-efficacy (73.52%), categorized as good.

Novelty/Originality of this study: The utilizing interactive tools such as Statcal, students can understand statistical concepts more deeply through a practical and contextual approach. This is relevant to be applied to statistics learning in schools and universities, especially in preparing students to face the challenges of the digital data era. In addition, this study also encourages teachers to integrate technology in learning to create a more engaging and effective learning experience.

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1. INTRODUCTION

In facing the Industrial Revolution 4.0, technological developments are developing rapidly and have overcome everything that was previously considered a waste of time, effort, and money, both through the development of tools and information systems. Technological developments in the industrial revolution 4.0, such as the Internet of Things, data science, artificial intelligence, robotics, cloud computing, 3D printing, and nanotechnology, have had a significant influence on all aspects of human life, including social, economic, cultural, and educational [1]-[3]. The most crucial thing is about development education, where technology has a significant influence. In development, technology in the world of education provides positive and negative impacts that deserve serious attention [4], [5].

Consequently, the quality of education encounters a new challenge: how learning changed in the era of the industrial revolution. The learning process in 4.0 must evolve alongside the pace of technological

development. The Industry 4.0 revolution is not only related to the development of technology but also involves human factors such as skills, creativity, and the ability to adapt to the changes associated with the era of society 5.0. Hence, development in education, gender, work, and mental health must follow and support development technology to take advantage of its potential and deliver a positive impact for society and the world in general [6], [7]. Change here is what automatic push change projection education or learning, i.e., maximizing literacy technology, Deep proficiency in understanding and using technology, information, and communication (ICT) is one important thing to do for teachers in 4.0 to remain relevant to developments and participant education [8]-[11].

Teachers 4.0 must master strong ICT literacy as a foundation to create participant-able students and compete in the era of the revolution of industry 4.0. In the current era of knowledge and technology, mathematics and statistics play a very important role in various human activities [12], [13]. These two disciplines, like twin brothers, play a crucial role in building quality Indonesian human resources. Both of them must work together to develop their respective scientific fields. Nonetheless, statistics and mathematics have different approaches to thinking: statistics tends to use an inductive-probabilistic approach, while mathematics uses a deductive-deterministic approach. This difference is a complementary force between statistics and mathematics. It is also important to note that statistics is not part of mathematics but is an independent scientific entity case [14], [15]. This linkage has resulted in special attention being paid to these two fields from the elementary school level to the tertiary level.

Currently available statistical teaching materials tend to be less interactive, focus on theory, and do not sufficiently support students' statistical literacy and self-efficacy. In addition, conventional learning approaches often fail to connect statistical concepts with practical applications in everyday life. There has not been much research that has developed technology-based teaching materials such as Statcal that are able to support the improvement of statistical competence holistically. However, it cannot be denied that some students, even university students, find mathematics and statistics difficult and less interesting based on the content and level of difficulty of the subject matter. The explanation states that identifying learning difficulties in statistics and mathematics, such as fear of mathematics and anxiety about statistics, causes a lack of student interest in learning these two subjects. As a result, this affects the achievement of student learning outcomes in mathematics and statistics [16]. The same thing was stated by Latifah, who stated that mathematics is a difficult subject, one of which is statistics material. In the higher education environment, including at Medan State University (Unimed), statistics subjects are usually taught separately and are not integrated with mathematics subjects [17].

Nevertheless, the role of mathematics is very important in determining students' success in understanding statistical concepts. In their 2006 book, Best and Khan explain that statistics is an integral part of the field of mathematics associated with the process of collecting, organizing, analyzing, and interpreting numerical data best [18]. Statistics involves a series of interesting phenomena and enables us to understand world situations related to decision-making and drawing conclusions [19]. Statistics serves as a tool that provides important indicators for initiating change and allows us to develop meaningful skills and abilities in making comparisons [20]. It is important to emphasize that in order to reach meaningful conclusions, knowledge and skills related to planning, research, and decision-making are very important [21]. Along with technological advances in the era of the Industrial Revolution 4.0, it is important for us to maintain a balance in our understanding of statistics by following the developments and literacy of various statistical programs currently being developed.

According to UNESCO (2004), literacy is defined as a person's ability to understand information, recognize, analyze, communicate, and calculate using print media sources, as well as write in a variety of contexts [22]. An understanding of literacy continue to develop and be applied in various fields, including information literacy, media literacy, scientific literacy, mathematical literacy, and statistical literacy. This is in line with the implementation of the independent curriculum in the literacy and numeracy movement. Literacy and numeracy are fundamental skills that are universal and important. The ability to think using language and mathematics is needed in a variety of situations, both in personal life, social interactions, and professional settings. Statistical literacy is the ability to understand, analyze, and use statistical data in decision-making, both individually and in a social context. Statistical literacy includes knowledge of basic statistical concepts, such as data distribution, probability, graphical representation, and interpretation of analysis results. This ability is very important in the modern era, where data is one of the main sources of information in various fields, including education, health, economics, and politics. Statistical literacy involves: 1) Data Understanding. Understanding the various types of data (qualitative and quantitative) and how they are collected; 2) Data Representation. The ability to read and create data representations such as tables, graphs, diagrams, or histograms; 3) Data Analysis. Identifying patterns, relationships, or trends from the data presented; 4) Data Interpretation. Making conclusions based on data and understanding the limitations or potential biases that exist; 5) Data Communication. Communicating statistical findings to others in a clear and relevant manner. Meanwhile, statistical literacy skills

are the practical aspect of statistical literacy, which refers to a person's ability to apply statistical concepts in real contexts.

Statistical literacy skills are an important need in the digital data era, where students must be able to analyze, interpret, and make decisions based on data. However, low statistical literacy of students is often accompanied by low self-efficacy in understanding statistical concepts. The development of innovative teaching materials such as Statcal is needed to overcome this obstacle and support more effective and relevant learning. These skills include not only technical knowledge of statistical methods, but also decision-making based on data. Some important statistical literacy skills include: 1) Identifying Relevant Information. The ability to select relevant data from various sources and understand the context of the data; 2) Using Statistical Tools. Understanding the use of statistical software (such as SPSS, Excel, or Python) and other analysis tools to process data; 3) Understanding the Concept of Error and Bias. Identifying measurement error, sampling bias, and how these factors affect the results of the analysis; 4) Thinking Critically About Data. Not only accepting raw data, but also checking the accuracy, credibility of the data source, and the validity of the analysis results; 5) Evaluating Claims Based on Data. Being able to analyze claims or arguments supported by data to assess whether the claim is logical and supported by strong statistical evidence.

In the current data-driven era, statistical literacy is one of the skills that every individual must have, especially in dealing with a flood of information that often contains bias or data manipulation. Statistical literacy helps individuals to: Make decisions based on valid data, respond critically to news or reports containing numbers and avoid manipulating information presented in the form of statistical data. Statistical literacy and statistical literacy skills are highly relevant competencies in the modern era. Not only does it support better decision-making, but it also helps people understand and communicate data-based information more effectively. Improving statistical literacy is an important step in building a society that is data literate, critical, and able to face the challenges of the digital era.

Takaria explained that, in the opinion of Gal, statistical literacy is very critical in interpreting and evaluating statistical information and argument-based data that appear in various media, as well as the ability to discuss these arguments [16]. Statistical literacy skills in statistics courses are considered important for students so they can understand both quantitative and qualitative data. This aims to prevent misinterpretation of data in the process of presentation, processing, analysis, and interpretation. Identified that students' statistical literacy skills could assist them in extracting qualitative information from quantitative data [23], [24]. Research has also identified that the lack of statistical literacy skills is caused by students' inability to apply them in their daily lives [25]-[30]. The operational definition of statistical literacy consists of five basic competencies: (1) understanding statistical concepts; (2) gaining insight into the application of statistical concepts; (3) developing computing and graphing skills; (4) interpreting skills; and (5) developing visualization and communication skills [31], [32]. From the experience of researchers in teaching statistics so far, students' statistical literacy skills are lacking. Students only understand statistical processing manually in Excel or SPSS.

Even though there are many applications out there, with the advancement of technology, there is an increasing number of them available for use, such as Lisreal, R, Minitab, Eviews, Statcal, PSPP, JASP, and many more. Lack of student literacy in statistical literacy is a setback in the development of industrial revolution 4.0 education. Besides having statistical literacy, students must have self-efficacy. Febriyansi & Cahaya Setiawan, define self-efficacy as one of the most influential aspects of self-knowledge in everyday human life [33]. According to Amalia & Indri self-efficacy is a skill that can be trained and taught to be better [34]. It can be said that self-efficacy is an important predictor of behavioral change as proposed by [35].

According to Lunenburg, individuals with high levels of self-efficacy have the belief that they are able to complete difficult tasks, while individuals with low levels of self-efficacy have the belief that they are only able to complete easy tasks [36]. Thus, a student needs to be given the opportunity to develop their self-efficacy.Self-efficacy beliefs are used as a performance-based measure so that they act as an influence to motivate student academic performance. As is the case with Vanhaltren's 2016 research, which explains the influence and linkage of self-efficacy as a motivator and as a contributor to individual academic performance [37]. So far, the lecturers for the statistics course have used statistics books to process data manually or with support from the SPSS application. Students are accustomed to doing data processing in a direct, guided manner.

Lack of courage to try things out and lack of self-confidence are two of the obstacles to learning, especially learning that emphasizes technology. For this reason, researchers want to develop statistics teaching materials so that students can follow the growing trend of statistical literacy by introducing a new statistics program, namely Statcal, with the aim of increasing statistical literacy and self-efficacy in mathematics education students. The title of the research is "Development of Statistical Teaching Materials Using Statistics to Improve Statistical Literacy and Self-Efficacy of Mathematics Education Students."Textbooks provide facilities to support independent learning activities, both in terms of content and presentation. The use of textbooks is part of a literacy culture and is an indicator of the progress of a society.

In the context of learning, textbooks have an important role. If the learning objective is to develop various competencies in students, then the textbook design must include certain principles, such as including

exercises based on multiple representations. Textbooks play an important role in helping students gain an understanding of the science concepts needed to achieve the desired competencies. Textbooks help convey information in an easy-to-understand way, including by explaining complex phenomena and abstract concepts, so that students can acquire relevant and realistic knowledge. This can motivate students to learn more actively and be involved in the learning process [38].

This study focuses on the development of interactive, applicable, and Statcal-based statistical teaching materials designed to improve students' understanding of statistical concepts while increasing their confidence in mastering the material. These teaching materials will be tested to measure their effectiveness in improving students' statistical literacy and self-efficacy. As for the selection of the statistical program in the development of textbooks to support statistical literacy, statistical is one of the new statistical applications that can be accessed free of charge and used online to process statistical data. Statistical Calculator, or STATCAL, is a statistical data processing application built by Prana Ugiana Gio in January 2017 [39].

2. RESEARCH METHOD

This research covers research and development (developmental research), which is research conducted to create specific goods and test their efficacy [40]. This development research was conducted to create the appropriate teaching materials and instruments, which were subsequently tested in the classroom. The sample was drawn at random from one of the classes, Bilingual Mathematics Education. Teaching material validation sheets, questionnaires on the effectiveness and practicality of teaching materials, and questionnaires to measure increased statistical literacy and self-efficacy using a Likert scale, which consists of four answer choices, were used in the study. Learning Device Development Model In research, the creation of 4-D model learning devices is divided into four stages: define, design, develop, and disseminate.

The research sample was students in grade X or XI (adjusted to the needs of the research) from one of the high schools selected by purposive sampling. This technique was used due to time constraints and certain criteria, such as students who had taken basic statistics subjects. Research Instrument, Statistical Literacy Instrument: A 4-point Likert scale-based questionnaire that measures students' ability to understand and use statistical data. Self-Efficacy Instrument: A 4-point Likert scale-based questionnaire that measures students' self-confidence in learning statistics. Observation Sheet: To evaluate the use of teaching materials during learning. Interview Guide: To explore students' and teachers' opinions about the effectiveness of teaching materials. The statistical literacy and self-efficacy instruments were tested for validity and reliability. The Cronbach's alpha values obtained from the trial were: Statistical Literacy: 0.85 (very reliable category) Self-Efficacy: 0.83 (very reliable category)

Data Collection, Development Stage: Validation of material and media experts on teaching materials using validation sheets and revision based on expert input. Implementation Stage: A pretest was given to measure students' statistical literacy and self-efficacy before using Statcal-based teaching materials. Learning using Statcal teaching materials. A posttest was conducted to measure the increase in students' statistical literacy and self-efficacy after learning. Data Analysis: Validity and Reliability Analysis: The validity of the instrument was tested using Pearson correlation analysis. Reliability was calculated using Cronbach's alpha value. Analysis of Pretest and Posttest Results: Data were analyzed using paired t-test to determine significant differences between the pretest and posttest. The effect of improvement is calculated using effect size (Cohen’s d). Qualitative Analysis: Data from observation sheets and interviews are analyzed descriptively to gain additional information about the effectiveness of the teaching materials.

3. RESULTS AND DICUSSION

Research that applies the 4-D development model goes through several stages. The objective is to describe the results of developing teaching materials that use statistics and their effectiveness in increasing students' statistical literacy and self-efficacy. The following are the results of the research based on the stages of the research model:

Defining Stage

The defining stage is useful for identifying and defining needs during the learning process, as well as obtaining knowledge about the product to be developed. Researchers analyzed the needs related to students, materials, and learning objectives. At this stage, it was found that many students were still lacking in mastering the development of statistics, as seen from the results of the analysis of the problem situations of fifth semester Mathematics Education students. The learning media used did not generate interest or motivation for students to study statistics. From the results of the analysis, researchers know what is needed to improve the quality of further learning, namely developing teaching materials that are able to increase statistical literacy and also foster

student self-efficacy. Based on the analysis of student characteristics in the fifth semester (V), students have been able to think at a higher level. This shows that they can learn independently.

Design Stage

At this stage, the development of teaching materials is carried out for use in learning the subject of inferential statistics in mathematics education. Teaching materials are developed by also inserting the use of a statistical application, namely Statcal. The selection of this application was carried out in addition to being an effort to introduce statistical applications to the Indonesian nation's children as well as adding students' insights about the knowledge and development of statistics and available statistical applications. The initial step is to choose a topic that matches the requirements of the inferential statistics material, as shown figure 1.

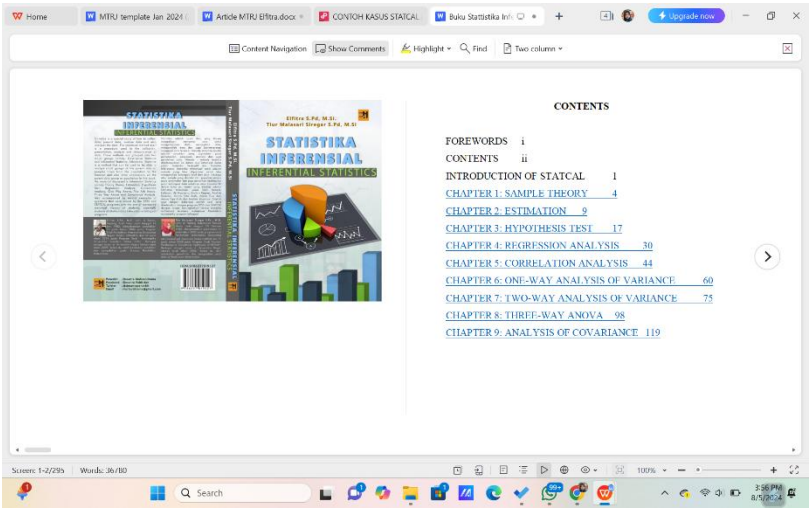

Figure 1. Subjects of Teaching Materials

Before entering the learning material, the lessons are given a complete introduction to the Statcal application, starting with the history of Statcal applications, the link to download, and how to download as shown figure 2.

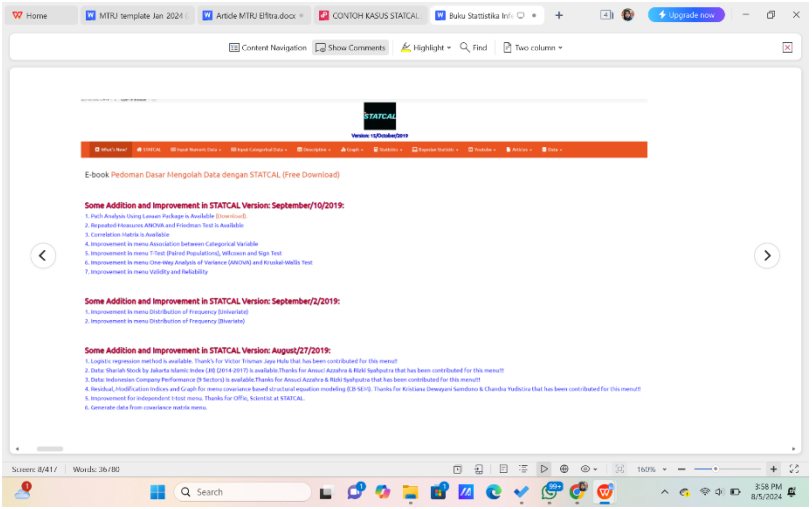

Figure 2. Section of Teaching Materials on Statcal Introduction

Each material is equipped with examples of questions solved using Statcal. The aim is to make it easier for students to master the subject matter even without the support of a tutor.

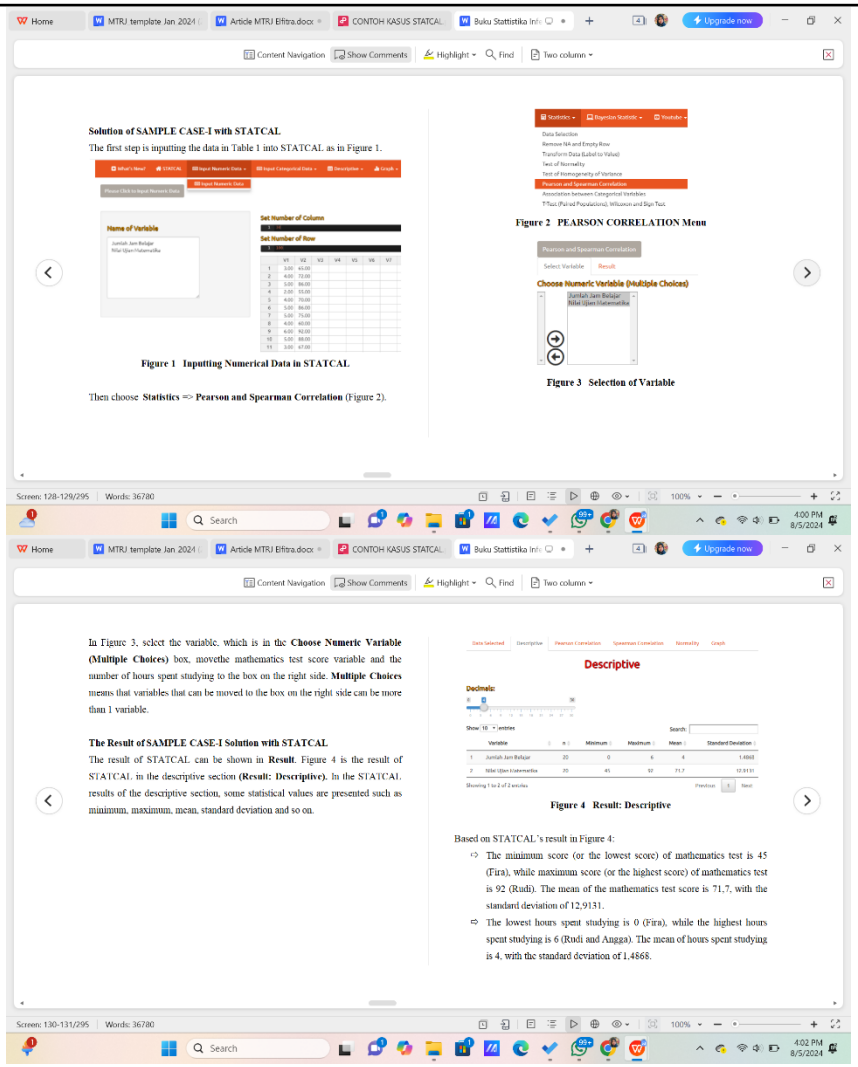

Figure 3. Examples of Tutorials using Statcal

Development Stage

This stage begins with validating the teaching materials that have been prepared. After analyzing the validation sheet given to three validation experts, the validation count is obtained as table 1.

Table 1. Acquired Material and Learning Expert Validation Results

Validator Name	Value	Criteria
Material Expert Validator	4.00	Valid
Material Expert Validator	4.27	Valid
Statcal Program Expert Validator	4.36	Valid
Averange	4.21	Valid
Criteria	Valid	

From Table 1, it can be concluded that the teaching materials developed are valid and can be tested on students in the limited field trial stage.

Dissemination Stage

The tryout was carried out with the research class group in the bilingual class inferential statistics course because the teaching materials were in English. The research was carried out accompanied by the provision of statistical literacy questionnaires, self-efficacy and practicality questionnaires, and the effectiveness of the statistics textbooks developed to determine the symptoms that become obstacles in the learning process and the research objectives. From the group data below, see the practicality and effectiveness of the teaching materials developed.

Table 2. Data on the Practicality Test Results for Teaching Materials

	Score	Persentase	Criteria
Average	30.14	83.72	Good

From table 2, it can be seen that the practicality of the trial value is 83.72 with good criteria; in other words, an inferential statistics book using practical statistics to useThe try-out was carried out with bilingual classes taking inferential statistics courses to see the English readability test for the teaching material being developed, namely inferential statistics books using statistics. The following are the results of the readability test of teaching materials in table 3.

Table 3. Data on the Readability of Teaching Materials

	Score	Persentase	Criteria
Average	40.66	81.32	Good

From the data shown in Table 3, it is evident that inferential statistics teaching materials using statistical methods have good readability, or, in other words, are easy to understand. These results were obtained through the provision of questionnaires to target students who use teaching materials. Apart from that, the findings from the results of direct communication with students during the learning process support the convenience of the existence of video tutorials to support the material in teaching materials.

Table 4. Student Response Data

Assessment	Like	Percentage	Dislike	Percentage
Aspects	15	83.3	3	16.7

After learning has been carried out for six weeks, students are given a questionnaire to measure their response to the use of the teaching materials provided. Based on table 4 above, overall, those who responded positively were 83.3%, while those who responded negatively were 16.7%. From the results of interaction and communication a week after learning, it was found that the percentage of dissatisfaction was higher because students had a low interest in learning the inferential statistics course.

Table 5. Student Activity Data

Student Activity	Meeting/week (%)						Average
	9	10	11	12	13	14	
	72.2	77.8	83.3	88.9	83.3	88.9	82.4

Based on table 5 above, the effectiveness of student activities during six lecture meetings was 82.4% in the good category. At this stage, a questionnaire was also distributed to measure statistical literacy and self-efficacy as well as the utilization of the teaching materials that were distributed.

The results of distributing statistical literacy and self-efficacy questionnaires were obtained as figure 4.

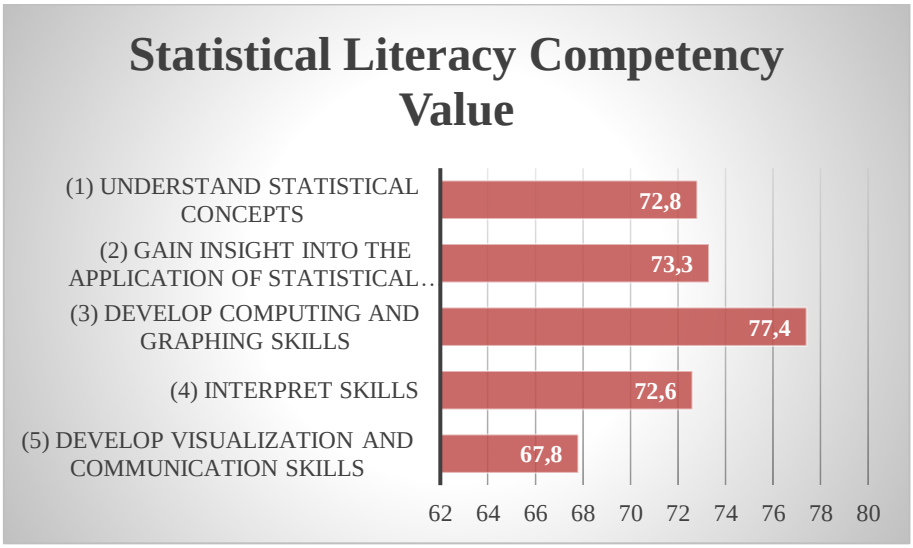

Figure 4. Student Statistical Literacy Competency Data

According to Figure 4, the results of calculating the statistical average for the five statistical literacy abilities indicate that bilingual class students have a statistical literacy level of 72.78%, which is considered good. Of the 5 statistical literacy competencies that are measured, it can be seen that the highest student competence is in competency 3, namely computational skills and making graphs. One of the important processes in statistics that is quantitative in nature is calculating and presenting calculations or data in graphical form. In addition to having a conceptual grasp and insight into the application of statistical ideas, skills in arithmetic and graphing are required. Using statistical applications increases student interest in this competency.

Of all the competencies to be measured, it appears that the pupils' vision and communication skills are the weakest. The assignment report shows that pupils struggle to understand what the researcher is saying. Similarly, when you can interpret research results from assignments that listeners do not comprehend, students' ability to describe the results of their calculations on paper or in presentations demonstrates their analytical skills. According to [41], statistical reasoning is the ability to collect, organize, analyze, and interpret statistical data to draw conclusions and make decisions based on statistical principles. Likewise, [42] reveals that statistical reasoning is a form of reasoning related to probabilistic numbers. Statistical reasoning is used to draw conclusions and make decisions in situations where the probability of opportunities cannot be disclosed or known with certainty. Thus, the capacity to understand data is one of the accomplishments in statistical thinking [43].

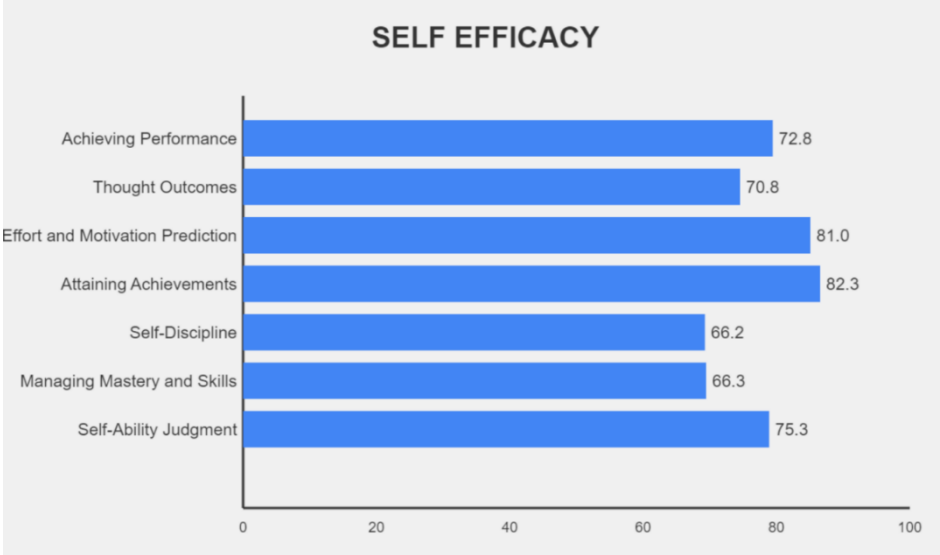

Figure 5. Data on the results of Self Efficacy Measures

To look at the impact on student self-efficacy and, by referring to some theories, a measurement angle with the following indicators of effectiveness: Achieving Performance, Thought Outcomes, Effort and Motivation Prediction, Attaining Achievements, Self-Discipline, Managing Mastery and Skills, and Self-Ability Judgment [44]-[49]. While the results of measuring student self-efficacy can be seen in Figure 5, with an average of 73.52% in the good category, Statistics teaching materials that use statistics help students' independence and confidence in solving statistical problems. Students have started to be able to manage their work and achieve goals, even though there is a lack of self-discipline. Self-efficacy is a person's assessment of their ability or competence to: 1) Perform a task. Self-efficacy relates to an individual's belief in their ability to complete a specific task, whether it is simple, such as completing homework, or complex, such as leading a team; 2) Achieve goals. Self-efficacy determines how confident a person is in their ability to achieve personal or professional goals; 3) Overcome obstacles. Self-efficacy also includes an individual's ability to face and overcome challenges or obstacles that arise along the way to achieving a goal. Four main sources that shape self-efficacy: 1) Mastery experiences. Previous success in performing a task increases self-efficacy, while failure can decrease it; 2) Observational learning. Seeing others succeed in performing a certain task can increase a person's belief that he or she is also capable of doing it; 3) Verbal persuasion. Support or encouragement from others (such as friends, teachers, or mentors) can increase self-confidence; 4) Physiological and emotional conditions. Physical and emotional conditions such as anxiety, stress, or fatigue can affect a person's perception of his or her abilities [50], [51].

This study reveals the importance of developing Statcal-based statistical teaching materials to improve students' statistical literacy and self-efficacy. Statistical literacy is a fundamental skill in the digital era, where data analysis and interpretation are highly needed skills. However, statistical learning in class is often theory-oriented with a less interactive approach, thus reducing students' interest and lowering their confidence in

learning this material. The results of the study show that Statcal-based teaching materials can improve students' statistical literacy. This is reflected in the increase in posttest results compared to pretest. Students are not only able to understand statistical concepts but are also more confident in imagining data analysis. Statcal, as an interactive and practical tool, facilitates learning based on real applications, so that students feel more connected to the material being studied. In addition, Statcal-based teaching materials are designed to meet students' needs for more active learning. Through data simulation, graphic visualization, and simple statistical analysis, students can learn independently and collaboratively. This contributes to increasing students' self-efficacy, where they feel able to complete statistical tasks that were previously considered difficult. Based on data analysis, paired t-test showed that there was a significant difference between the pretest and posttest results for both statistical literacy and student self-efficacy. The high effect size value also indicates that Statcal-based teaching materials have a major impact on improving both aspects. This finding is in line with the theory of technology-based learning which states that technology integration can improve student motivation and learning outcomes. However, this study has limitations, such as the sample being limited to one school so that the results cannot be generalized widely. In addition, the relatively short implementation time may affect the results obtained. However, these findings provide a strong basis for further research and broader implementation in statistics learning. Overall, the development of Statcal-based teaching materials provides an innovative solution to overcome challenges in statistics learning. Not only does it support mastery of statistical material, but it also helps students build self-confidence in facing the challenges of the digital data era.

4. CONCLUSION

The development of statistical teaching materials using Statcal through several development processes, validated by material experts and media experts, produced valid teaching materials with a value of 4.21 based on the results of the analysis and findings collected during the study. The practicality test showed a percentage of 83.72% in the good category, the readability test showed a percentage of 81.32% in the good category, and the effectiveness test showed a percentage of 82.4% in the good category. Measuring statistical literacy and student self-efficacy is the main objective of creating statistical teaching materials with Statcal. Students' abilities in statistical literacy are in the good range, but there are still weaknesses in terms of interpretation skills and visualization skills and communication of work results. The level of student self-efficacy is already in the good category, but weak in self-discipline, mastery, and skill regulation. In the process of developing statistical teaching materials, the use of statistics can be one of the right tools to develop statistical literacy and student self-efficacy.

ACKNOWLEDGEMENTS

Acknowledgments are addressed to Medan State University as a forum for researchers in developing science, the Research and Community Service Institute (LPPM), the Faculty of Mathematics and Natural Sciences (FMIPA), and the Unimed Mathematics Department for providing facilities and infrastructure support in carrying out this research.

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