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RME-based e-worksheets with Liveworksheet: A tool to enhance mathematical conjecturing abilities in statistics learning

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ABSTRACT

This research is motivated by the low ability of students to make mathematical conjectures in statistics learning, especially on the topic of measures of central tendency, which is caused by the lack of interactivity and student involvement in mathematics learning. To overcome this, the study aims to develop and analyze the effectiveness of Electronic Student Worksheets (E-LKPD) based on Realistic Mathematics Education (RME) with Liveworksheet as an interactive learning medium. This study uses a research and development method (R&D) with a quasi-experimental design. The subjects of the study were seventh-grade junior high school students who participated in statistics learning. Data were collected through a mathematical conjecture ability test, observation of student engagement, and a questionnaire of student responses to the learning medium. The results showed that E-LKPD based on RME with Liveworksheet significantly improved students' mathematical conjecture abilities, as evidenced by the increase in average scores before and after the use of the media. In addition, students showed high enthusiasm and active involvement during the learning process. In conclusion, the use of E-LKPD based on RME with Liveworksheet is effective as a tool to improve mathematical conjecture abilities in statistics learning, while increasing student motivation and participation.

INTRODUCTION

The world has entered the era of the Industrial Revolution 4.0, where technology has become an essential part of human life. The development of Information And Communication Technology (ICT) has had a significant impact on various fields, including education. Technology not only facilitates the delivery of material between teachers and students but also has the potential to improve the quality of learning (Afriani, 2022; Amir et al., 2018).

One form of ICT application in education is the use of multimedia-based learning media, such as e-modules, Canva, and Liveworksheet. These media enable learning to be more interactive, engaging, and relevant to real-life contexts. Interactive multimedia combines words, images, and animations to increase student motivation and understanding. Interactivity in mathematics, in particular, is crucial because many students struggle to grasp mathematical concepts and lack motivation due to uninteresting teaching materials (Fiani et al., 2024; Meilina & Andriani, 2023).

Liveworksheet is a tool that transforms traditional worksheets into interactive online worksheets. This tool can be designed for various topics, including statistics learning, particularly in determining measures of central tendency. Mathematical problems are often difficult to solve because students lack the ability to transform verbal statements into mathematical models or interpret solutions in real-life contexts (Mumu & Tanujaya, 2018; Nurjanah & Angraini, 2024). Therefore, mathematics learning must be designed to develop students' logical, analytical, systematic, critical, creative, and collaborative thinking skills.

Mathematical conjecture is a crucial skill in mathematics learning. This ability allows students to validate mathematical statements or problems informally through observation, experimentation, and investigation, before being formally proven (Prihandono et al., 2023; Rabbani & Herman, 2017). Indicators of mathematical conjecture include observation, investigation, exploration, and inquiry, which require students to listen, read carefully, identify hidden assumptions, and evaluate the consequences of mathematical statements.

Previous research has demonstrated the effectiveness of the Realistic Mathematics Education (RME) approach and interactive media in improving students' critical thinking and mathematical conjecture skills. Afriani (2022) found that RME can improve elementary school students' critical thinking skills in science learning. Amir et al. (2018) demonstrated that interactive multimedia based on problem-solving improves students' mathematical reasoning skills. Meilina & Andriani (2023) reported that implementing TPACK (Technological Pedagogical Content Knowledge)-based Liveworksheets increased motivation and critical thinking skills in science learning. Prihandono et al. (2023) demonstrated that RME-based e-LKPD with Liveworksheets effectively improved students' mathematical conjecture skills. However, previous research has been limited to science or general mathematics learning contexts and has not emphasized its application to statistics topics, particularly measures of central tendency, creating a gap that needs to be addressed through this research.

Furthermore, mathematics learning in the classroom is often passive because teachers still predominantly use the lecture method. This makes students less active in learning activities. The use of Liveworksheets in Indonesia is still limited, so the potential of this medium to support the RME approach is not yet optimal (Putri & Sukmaningthias, 2025; Sutarni et al., 2024; Thorndahl & Stentoft, 2020). The novelty of this research lies in the development of an RME-based electronic worksheet using Liveworksheets to improve students' mathematical prediction skills in statistics learning. A limitation of this study is the limited sample size of one junior high school class, so the results may not be fully representative of the broader population.

Based on the description above, this study aims to develop and analyze the effectiveness of an RME-based electronic worksheet using Liveworksheets as an interactive learning medium in improving students' mathematical prediction skills on the topic of measures of central tendency in statistics learning.

RESEARCH METHODS

This research is a Research and Development (R&D) project aimed at producing multimedia mathematics learning based on Realistic Mathematics Education (RME) on the topic of central tendency measures in grouped data for 12th-grade high school students (Prihandono et al., 2023). This research was chosen because it focused on designing, developing, and testing the effectiveness of interactive learning media in improving students' mathematical conjecture skills (Choirudin et al., 2025). The subjects and objects of this research consisted of 12th-grade high school students at a school in (mention location if known), with a total of 30–35 students. The object of this research was the RME-based electronic worksheet (LKPD) developed using the Liveworksheet application, while the subjects were the students who used the electronic worksheet in their learning process (Meilina & Andriani, 2023).

The media development process follows the R&D development model, which consists of needs analysis, product design, expert validation, limited trials, and final product revision (Gustiani, 2019). Based on the needs analysis conducted through questionnaires and initial interviews with teachers and students, several characteristics were identified that demonstrate the advantages of this multimedia, namely attractiveness, practicality, and accessibility anytime and anywhere (Meilina & Andriani, 2023). In the implementation phase, students were given RME-based e-LKPD through Liveworksheet. Student activities included: (1) watching an instructional video explaining the concept of measures of central tendency, (2) applying the concept to real-life problem-solving tasks, and (3) completing interactive worksheets in Liveworksheet to develop their mathematical conjecture skills (Afriani, 2022).

The data collection method used a combination of qualitative and quantitative methods, including pre- and post-learning mathematical conjecture ability tests to assess student improvement. Student engagement was observed during the learning process using observation sheets (Vilianti et al., 2018). A student response questionnaire was used to measure student motivation and perceptions of the interactive e-LKPD (Rizki et al., 2023). Data analysis methods included quantitative analysis: calculating the average value and improvement in conjecture ability test scores before and after learning. Simple statistical tests, such as paired t-tests, were used to determine the significance of student improvement (Afifah et al., 2022). Qualitative analysis analyzed observation and questionnaire data using thematic descriptive analysis to evaluate student engagement, perceptions, and the strengths and

weaknesses of the learning media (Febrina & Setiawan, 2024).

The results were then presented in the form of test score comparison tables, student engagement diagrams, and a summary of qualitative findings, facilitating a better understanding of the effectiveness of the RME-based e-LKPD using Liveworksheet in improving students' mathematical conjecture ability in statistics learning.

The workflow of the research is illustrated in the following diagram:

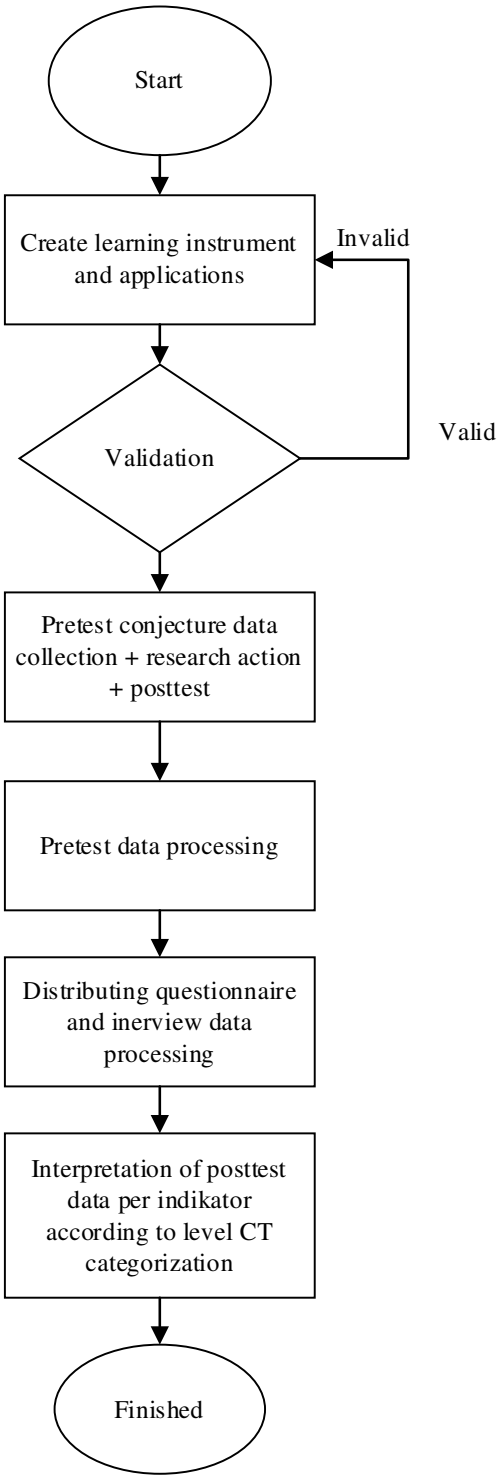

Figure 1. The workflow of the research

This flowchart illustrates the process of creating and validating learning instruments and applications used in the research. The process begins with instrument creation, followed by validation to ensure validity. If valid, data collection continues through pretests, research observations, and posttests. Pretest data is then processed before distributing questionnaires and conducting interviews. Next, data from the questionnaires and interviews is processed, and posttest results are interpreted based on indicators according to the CT (Critical Thinking) level categories. Once all stages are completed, the process is declared complete.

RESULTS AND DISCUSSION

Result

The development of the media was carried out after conducting a needs analysis in response to the demands of modern times. Once the media was ready, it was validated by users, subject-matter experts, and media experts by evaluating several aspects to determine the feasibility percentage for classroom implementation. The results of the validation by subject-matter experts are shown in Table 1.

Table 1. Validation Results by Subject-Matter Experts

No.	Indicator	Score	Description
1	The learning objectives are in line with the core and basic competencies.	4	Very Feasible
2	The content in the worksheet corresponds to the core and basic competencies.	4	Very Feasible
3	The content can be easily understood by students.	3	Very Feasible
4	Illustrations are consistent with the content of the worksheet.	3	Feasible
5	The problems presented are related to students' tasks and environment.	3	Feasible
6	The language used in the worksheet is easy to understand.	3	Feasible
7	The worksheet can be studied anytime and anywhere.	3	Feasible
8	The worksheet can be studied without additional media.	3	Feasible
9	The content of the worksheet matches the core and basic competencies.	4	Very Feasible
10	The worksheet content is aligned with the development of science and technology.	4	Very Feasible
	Total	34	
	Percentage	85%	Very Feasible

Based on Table 1, the validation results from subject-matter experts indicate that the developed e-LKPD is suitable for classroom implementation, as it achieved an 85% score categorized as "Very Feasible". Next, validation was conducted by media experts, as presented in Table 2.

Table 2. Validation Results by Media Experts

No.	Indicator	Score	Description
1	Suitability of size with the content of the worksheet.	3	Feasible
2	Layout arrangement on the cover and spine is appropriate/harmonious.	3	Feasible
3	Illustrations reflect the content/material of the worksheet.	3	Very Feasible
4	Use of font variations (bold, italic, capital, small capital) is not excessive.	3	Feasible
5	The media is easy to use.	3	Feasible
6	The media language is easy to understand.	3	Feasible
7	White space usage is adequate.	3	Feasible
8	Color combination is appropriate.	3	Feasible
9	The media can be used anytime.	4	Very Feasible
10	Originality of the media design.	4	Very Feasible
	Total	32	
	Percentage	80%	Feasible

Based on Table 2, the validation results from media experts show that the developed E-LKPD is also feasible for classroom implementation, as it achieved an 80% score categorized as "Feasible." The next stage involves presenting the validation results from students' assessments of the application, the details of which are provided in the appendix. A summary of these results is presented in Table 3.

Table 3. Recapitulation of User Responses

Statement	Strongly Disagree	Disagree	Agree	Strongly Agree	Total Score	Total Percentage
Usefulness	0 (0%)	7 (8.8%)	52 (65%)	21 (26.3%)	80	100%
Easy to use	0 (0%)	19 (17.3%)	61 (55.5%)	30 (27.3%)	110	100%
Easy to learn	0 (0%)	7 (17.5%)	23 (57.5%)	10 (25.0%)	40	100%
Satisfaction	0 (0%)	10 (14.3%)	45 (64.3%)	15 (21.4%)	70	100%

Table 3 shows that in the "Usefulness" category, most students responded *agree* with a score of 65%. In the "Easy to use" category, the *agree* score was 55.5%. For "Easy to learn," the *agree* score was 57.5%, and in the "Satisfaction" category, the *agree* score was 64.3% regarding the development of the student worksheet using the Liveworksheet application. A graphical analysis of these results is presented in Figure 2.

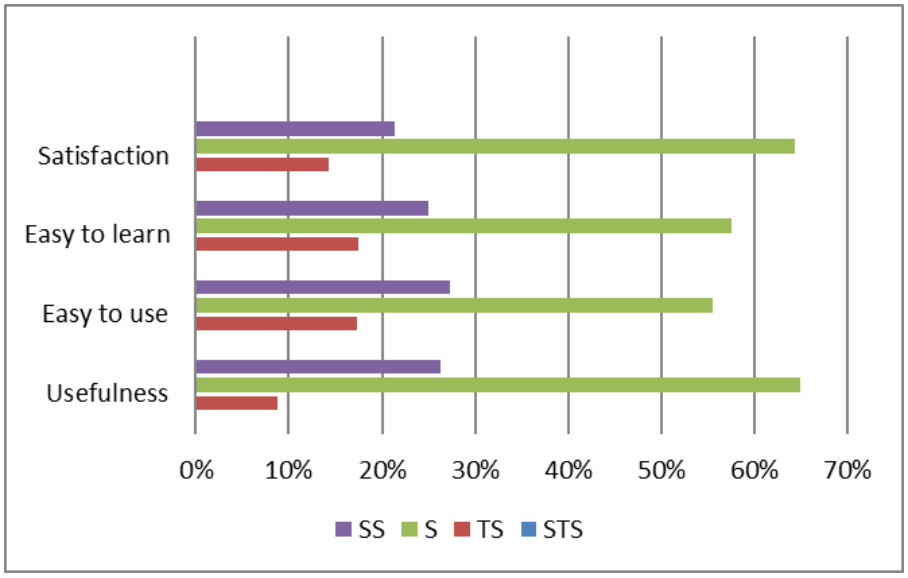

Figure 2. User Response Graph

Figure 2 shows that some users still considered the Liveworksheet application less effective (score 2). However, the majority of users rated it as good or very good across all aspects. The calculations show the average scores as follows: 3.04 (Usefulness), 3.06 (Easy to use), 3.00 (Easy to learn), and 2.96 (Satisfaction) on a maximum scale of 4. The overall average across all categories is 3.02, indicating that the application is feasible for use.

The multimedia was developed with strong relevance to the subject matter, focusing on the concept of probability theory as one of the fundamental topics in mathematics. Probability theory is a branch of mathematics that studies the likelihood or chance of an event occurring, expressed in values ranging from 0 (impossible event) to 1 (certain event). The multimedia presents this concept not only through textual explanations but also by using visual representations such as interactive diagrams, animations, and simulations. For instance, students can observe how probabilities change dynamically when the number of trials in an experiment increases, helping them develop an intuitive understanding of theoretical probability and its relationship with experimental probability. This approach ensures that abstract mathematical ideas are made more concrete and accessible to learners, as shown in Figure 3.

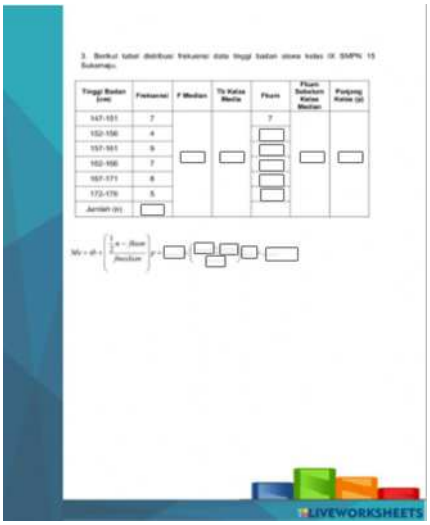

Figure 3. Relevance of Content in Multimedia

The multimedia also shows that it fits well with the learning plan that is laid forth in the student worksheet (Figure 4). The content covers the Basic Competencies (*Kompetensi Dasar*) of figuring out and analysing measures of central tendency and solving issues with histograms and frequency distribution tables. The goal of each interactive game is to assist students meet the competency indicators, such figuring out the mean, median, and mode of grouped data and understanding what they signify.

Figure 4. Relevance of Learning Strategy in Multimedia

The multimedia also complements the Problem Based Learning (PBL) paradigm and encourages students to work together, as the worksheet says. Students are told to look at real-world evidence, talk about what they find in groups, and work together to solve challenges. The multimedia's interactive features and instant feedback help students understand concepts better and improve their critical thinking and problem-solving skills.

The multimedia makes sure that students learn actively and via inquiry by combining relevant content with a well-planned learning strategy. This integration connects theory and practice, helps students understand probability concepts better, and fits with curriculum goals and classroom teaching methods, making it a strong and pedagogically sound way to learn.

Discussion

This research is the development of an Electronic Student Worksheet (E-LKPD) based on Realistic Mathematics Education (RME) using Liveworksheet to improve mathematical conjecture skills in 12th-grade high school students. Based on a needs analysis, this multimedia learning program demonstrates several advantages: it is engaging, practical, and accessible anytime and anywhere. The multimedia learning program was created using the Liveworksheet application.

Thorndahl & Stentoft (2020) found diverse perspectives on the relationship between Realistic Mathematics Education (RME) and critical thinking in higher education, noting that explicit explanations of this relationship are often lacking. Yohannes & Chen (2024) reported a positive relationship between RME and critical thinking among nursing students. Afriani (2022) demonstrated the effectiveness of RME in improving mathematical conjecture skills among fifth-grade science students. Öksüz et al. (2022) found that RME positively impacts academic achievement in secondary education, although evidence of its superiority over traditional teaching methods is not entirely consistent.

This study bridges this gap by integrating RME syntax with mathematical conjecture ability indicators in the developed E-LKPD. Validation by material experts indicates that the material aligns with the mathematical conjecture indicators, with a score of 85%, categorized as very appropriate. This result aligns with the findings of Yu & Zin (2023), who reviewed the RME model oriented toward critical thinking and confirmed its effectiveness in improving conjecture ability.

Meanwhile, validation by media experts yielded a score of 80% (adequate), consistent with the research of Prihandono et al. (2023), who found that RME-based Electronic Student Worksheets (E-LKS) assisted by Liveworksheet effectively improved mathematical conjecture skills and physics learning outcomes.

User feedback indicated that some students considered the application less effective, but the majority gave positive assessments. The average scores were 3.04 for usability, 3.06 for ease of use, 3.00 for ease of learning, and 2.96 for satisfaction, with an overall average of 3.02 on a scale of 4. This demonstrates the app's feasibility in the classroom.

Furthermore, Meilina & Andriani (2023) reported that Liveworksheet-based Technological Pedagogical Content Knowledge (TPACK) significantly influenced elementary school students' learning motivation and critical thinking in science. Rizki et al. (2023) also found that students' mathematical conjecture skills were high (82.1%) in cooperative learning supported by Liveworksheet. These findings reinforce the belief that Liveworksheet, combined with Realistic Mathematics Education (RME), can effectively improve mathematical conjecture skills in various fields, including physics and science, while also fostering critical thinking.

CONCLUSION

The results of this research and development indicate that the student worksheets developed using the Liveworksheet application are suitable for use, with a good rating, with an average score of 3.02. This indicates that the product can effectively support student learning and can be reused or further developed for future learning purposes. Most students were able to participate effectively in the learning activities, as the use of these worksheets not only supported the learning process but also encouraged the development of students' critical thinking.

The implications of this research for education are the importance of utilizing digital technology such as Liveworksheet in mathematics learning, particularly in the topic of measures of central tendency. This technology integration can enrich learning methods and provide a more interactive learning experience for students. However, further research is needed to explore in depth how the principles of central tendency can be effectively implemented through this platform. Furthermore, special attention needs to be paid to time management during often limited face-to-face learning sessions to ensure optimal implementation of Liveworksheet in the future.

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