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EFFECTIVENESS OF EDUCAPLAY GAME-BASED LEARNING WITH THE CTL APPROACH TO IMPROVE STUDENTS' MATHEMATICAL COMMUNICATION SKILLS

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ABSTRACT
This study was conducted to address the low level of students' mathematical communication skills in learning mathematics. It aimed to develop a game-based mathematics learning media using Educaplay integrated with the Contextual Teaching and Learning (CTL) approach to improve students' mathematical communication skills on relations and functions material. The research was carried out at a junior high school involving 28 eighth-grade students. This study employed a Research and Development (R&D) method using the ADDIE model. Data were collected through expert validation sheets, student response questionnaires, and mathematical communication skill tests (pre-test and post-test).The results showed that the developed media was valid and feasible to use. The effectiveness test indicated an I ncrease in students' average score from 51.92 in the pre-test to 76.82 in the post-test, with an N-Gain score of 0.56 (moderate category). This improvement reflects a moderate increase in students' mathematical communication skills, particularly in visual representation and mathematical expression indicators. However, the improvement in written communication skills was relatively lower.These findings suggest that Educaplay-based learning media with the CTL approach is effective in improving students' mathematical communication skills, although further development is needed to optimize written communication aspects.
Keywords: CTL; educaplay, learning media; mathematical communication kills

ABSTRAK
Penelitian ini dilatarbelakangi oleh rendahnya kemampuan komunikasi matematis peserta didik dalam pembelajaran matematika. Penelitian ini bertujuan untuk mengembangkan media pembelajaran matematika berbasis game Educaplay yang terintegrasi dengan pendekatan Contextual Teaching and Learning (CTL) guna meningkatkan kemampuan komunikasi matematis peserta didik pada materi relasi dan fungsi. Penelitian dilaksanakan di salah satu SMP dengan melibatkan 28 peserta didik kelas VIII. Metode yang digunakan adalah Research and Development (R&D) dengan model ADDIE. Teknik pengumpulan data meliputi lembar validasi ahli, angket respons peserta didik, serta tes kemampuan komunikasi matematis (pre-test dan post-test). Hasil penelitian menunjukkan bahwa media yang dikembangkan dinyatakan valid dan layak digunakan. Uji efektivitas menunjukkan adanya peningkatan rata-rata nilai peserta didik dari 51,92 pada pre-test menjadi 76,82 pada post-test dengan nilai N-Gain sebesar 0,56 yang termasuk kategori sedang. Peningkatan tersebut menunjukkan adanya peningkatan kemampuan komunikasi matematis peserta didik pada kategori sedang, terutama pada indikator representasi visual dan ekspresi matematis. Namun, peningkatan pada aspek komunikasi tertulis masih relatif lebih rendah. Dengan demikian, media pembelajaran berbasis Educaplay dengan pendekatan Contextual Teaching and Learning (CTL) cukup efektif dalam meningkatkan kemampuan komunikasi matematis peserta didik, meskipun masih diperlukan pengembangan lebih lanjut untuk mengoptimalkan aspek komunikasi tertulis.
Kata kunci: *CTL; educaplay, kemampuan komunikasi matemati;, media pembelajaran*

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Introduction

Education is a fundamental foundation in developing individual quality and determining the progress of a nation (Rasyid & Syuaib Alfareza, 2024). Through education, human potential can be developed in a directed and systematic manner (Regia Andini et al., 2024). The National Education System Law No. 20 of 2003 emphasizes that education is a conscious effort to create a learning process that enables students to actively develop their potential (Hakim, 2016). In a global context, education also plays an important role in supporting sustainable development and improving the quality of life of society (Jarin Akhter, 2020). In mathematics learning, one of the essential competencies is mathematical communication skills, defined as students' ability to express mathematical ideas through oral language, written text, symbols, and visual representations (Cai et al., 1996; NCTM, 2000).

However, students' mathematical literacy in Indonesia is still relatively low (Kemendikbudristek, 2024). The results of the Programme for International Student Assessment (PISA) 2022 indicate that Indonesian students' ability to understand and apply mathematical concepts remains below the OECD average (PISA 2022 Results (Volume I), 2023). This condition highlights an urgent need to develop innovative and adaptive learning strategies to improve students' mathematical communication skills (Hidayah Ngurahrai & Desy Farmaryanti, 2019).

The low level of students' mathematical communication skills is closely related to learning processes that are still conventional and provide limited opportunities for active interaction (Asoraya & Ruli, 2023). Students tend to be passive and focus primarily on solving problems without understanding the underlying thinking processes (Suhenda & Munandar, 2023). Based on observations conducted at SMPN 1 Labuhan Maringgai, students experienced difficulties in explaining solution procedures systematically, visualizing concepts, and communicating mathematical ideas in written form.

Empirical data indicate that students' mathematical expression ability reached 48%, writing ability 38%, and visual representation ability 26%. The results of the questionnaire also revealed that students showed greater interest in digital game-based learning. These findings are supported by previous studies (Zakiyah et al., 2024; Witri & Adi Ihsan Imami, 2022), which report that students' mathematical communication skills remain at low to moderate levels.

Over the past decade, studies have shown that the use of game-based learning in mathematics education can enhance students' motivation, engagement, and learning outcomes (Huang & Lin, 2022; von Bertalanffy et al., 2015). Digital platforms such as Educaplay enable interactive learning environments, provide immediate feedback, and encourage active student participation (Aisyah et al.,, 2025). This is consistent with the characteristics of the digital generation, which tends to be more responsive to technology-based learning (Permana et al., 2024).

In addition, the Contextual Teaching and Learning (CTL) approach has been proven effective in helping students connect mathematical concepts with real-life situations, thereby making learning more meaningful (Johnson, 2002). This

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approach is supported by modern constructivist theory, which emphasizes that knowledge is constructed through active learning experiences and social interaction (Mykytka et al., 2022). Furthermore, the integration of digital media with CTL is reinforced by multimedia learning theory, which states that the combination of text, visuals, and interactivity can significantly enhance conceptual understanding (Mayer, 2010).

Although numerous studies have examined the use of digital media and contextual approaches in mathematics learning, a research gap remains. Specifically, there is limited research that integrates Eduplay-based game learning media with the Contextual Teaching and Learning (CTL) approach to enhance students' mathematical communication skills, particularly on the topic of relations and functions at the junior high school level. Most previous studies have primarily focused on improving general learning outcomes or have applied only one of these approaches independently.

Based on the aforementioned considerations, the novelty of this study lies in the systematic development and integration of Educaplay-based game learning media with the Contextual Teaching and Learning (CTL) approach to improve students' mathematical communication skills, particularly on the topic of relations and functions.

Therefore, this study aims to develop Educaplay-based game learning media integrated with the Contextual Teaching and Learning (CTL) approach, as well as to examine its validity, attractiveness, and effectiveness in improving students' mathematical communication skills.

Research Methods

This study employed a Research and Development (R&D) approach by adopting the ADDIE model, which consists of five main stages: analysis, design, development, implementation, and evaluation (Molenda, 2003). The schematic of the ADDIE model stages is presented in Figure 1. The entire development process in this study was carried out systematically following the sequence of the ADDIE model.

At the analysis stage, the researcher identified needs through preliminary observations conducted at SMPN 1 Labuhan Maringgai, curriculum analysis, and analysis of students' characteristics. In addition, an analysis was carried out on students' difficulties in mathematical communication skills related to the topic of relations and functions, as well as an analysis of the need for digital-based learning media.

At the design stage, the researcher developed the learning media design in the form of flowcharts and storyboards, as well as determined the types of activities to be implemented on the Educaplay platform. In addition, research instruments were prepared, including expert validation sheets, student response questionnaires, and mathematical communication skill test items based on predetermined indicators.

At the development stage, the researcher began developing the learning media product using the Educaplay platform based on the previously designed framework. The developed product was then validated by material and media experts to assess its content feasibility, visual design, and instructional aspects. The validation results were used as a basis for revising and improving the product.

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At the implementation stage, the revised learning media was tested on students through small-group and large-group trials. During this stage, the researcher also collected data using student response questionnaires and administered pre-test and post-test assessments to measure the improvement in students' mathematical communication skills.

At the evaluation stage, the researcher conducted an evaluation of the entire development process and outcomes, including the feasibility, attractiveness, and effectiveness of the learning media. The evaluation was carried out both formatively at each stage and summatively at the end of the study to refine and improve the final product.

The results of the development process are presented in Figure 2. Based on the figure, the final product is an Eduplay-based game learning media integrated with the Contextual Teaching and Learning (CTL) approach on the topic of relations and functions. The product has undergone expert validation to ensure the appropriateness of its content, visual design, and pedagogical aspects. Furthermore, the media was tested through small-group and large-group trials to determine its feasibility and to obtain students' responses. Based on the evaluation results, the media was found to meet the criteria of being feasible and attractive, indicating that it is suitable for use in the learning process. In Figure 1.

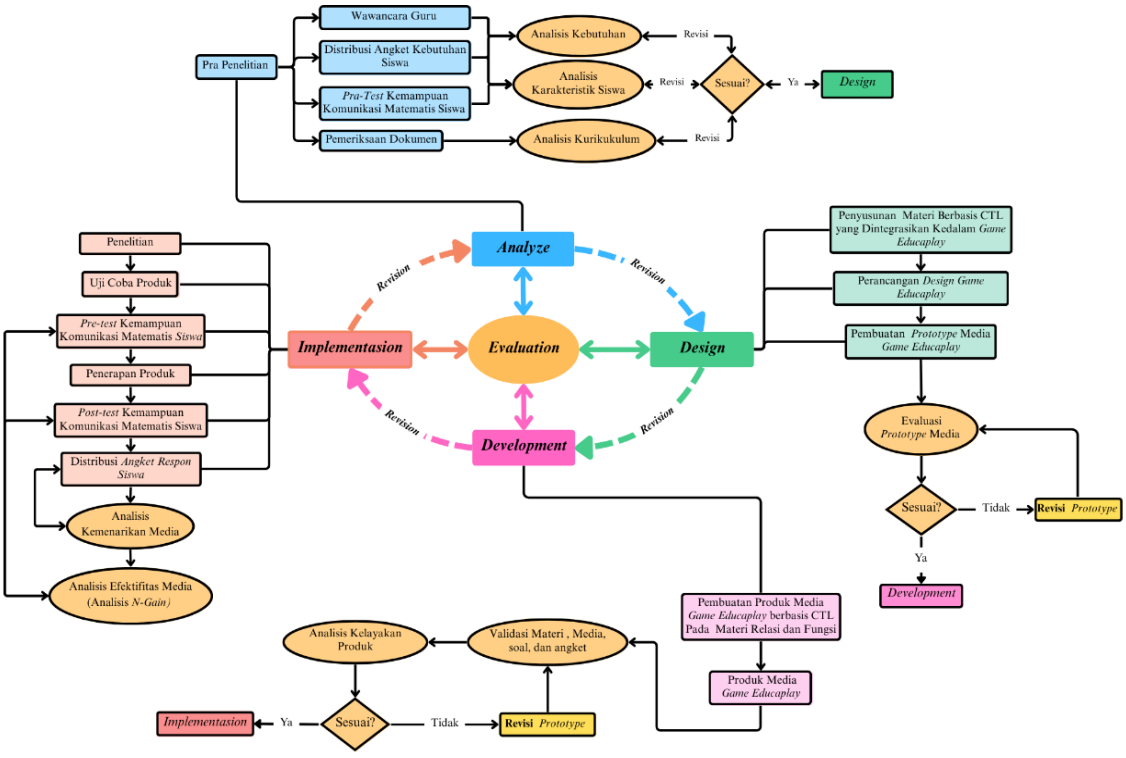

Figure 1. Stages of the ADDIE Development Model

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Educaplay-Based Game Learning Media with the CTL Approach in Figure 2.

Figure 2. Educaplay-Based Game Learning Media with the CTL Approach

The focus of this study is to examine the effectiveness of using Educaplay-based game learning media integrated with the Contextual Teaching and Learning (CTL) approach in improving students' mathematical communication skills on the topic of relations and functions. The subjects of this study consisted of 28 eighth-grade students at SMPN 1 Labuhan Maringgai.

The data analysis technique in this study employed a quantitative descriptive approach. Data obtained from media expert validation, material expert validation, and student response questionnaires were analyzed by calculating the mean score for each assessment aspect. The resulting scores were then converted into feasibility categories based on predetermined criteria. This analysis aimed to determine the level of feasibility of the developed media and instruments, as well as to systematically describe the results of the small-group and large-group trials.

Data collection was carried out using pre-test and post-test instruments. The assessment of students' mathematical communication skills was based on the indicators proposed by Cai, Jakabcsin, and Lane, which include written text ability, drawing ability, and the ability to express ideas in the form of mathematical expressions (Cai et al., 2010).

The pre-test and post-test data were analyzed using the Normalized Gain (N-Gain) formula to determine the magnitude of improvement in students' mathematical communication skills. The N-Gain was calculated by comparing the pre-test and post-test scores with the maximum possible score, as expressed in Equation (1):

$$\frac{\left(\%\langle S_f\rangle - \%\langle S_i\rangle\right)}{\left(100 - \%\langle S_i\rangle\right)} \ldots\ldots (1)$$

Where: $\langle g\rangle =$ normalized gain; $\langle S_f\rangle =$ mean post $-$ test score; $\langle S_i\rangle =$ mean pre $-$ test score; $100 =$ ideal maximum score. The results of the calculation were then interpreted based on the criteria presented in Table 1.

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Table 1. N-Gain Criteria

Range	Category
$\langle g \rangle \geq 0{,}7$	High
$0{,}3 \leq \langle g \rangle < 0{,}7$	Moderate
$\langle g \rangle < 0{,}3$	Low

(Hake, 1998)

The N-Gain values were classified into three categories: high if ⟨g⟩ ≥ 0.7, moderate if 0.3 ≤ ⟨g⟩ < 0.7, and low if ⟨g⟩ < 0.3. This classification was used as the basis for evaluating the level of improvement in students' mathematical communication skills based on the comparison between pre-test and post-test results, as well as for determining the effectiveness of the Educaplay-based learning media integrated with the Contextual Teaching and Learning (CTL) approach developed in this study.

Results and Discussion

The development stage was carried out through validation by media experts and material experts. The validation results indicated that the learning media obtained a score of 3.52 and the material obtained a score of 3.65, both of which were categorized as feasible for use. At the implementation stage, the media was tested in small-group (12 students) and large-group (28 students) trials. The results showed that the level of attractiveness reached a score of 3.25 (attractive category) in the small group and 3.31 (very attractive category) in the large group.

In addition, the material expert validation of the test items yielded a score of 2.94, which falls into the very good (feasible) category. The validation of the student response questionnaire obtained a score of 2.89, also categorized as very good (feasible). Thus, the test items based on the Contextual Teaching and Learning (CTL) approach, as well as the student response questionnaire, were deemed feasible and appropriate for use in the learning process.

The effectiveness of the Educaplay-based game learning media integrated with the Contextual Teaching and Learning (CTL) approach was analyzed by comparing students' pre-test and post-test scores on mathematical communication skills in the topic of relations and functions. The pre-test was administered to identify students' initial abilities prior to the use of the developed media. Examples of students' responses at the initial stage are presented in Figures 3 and 4.

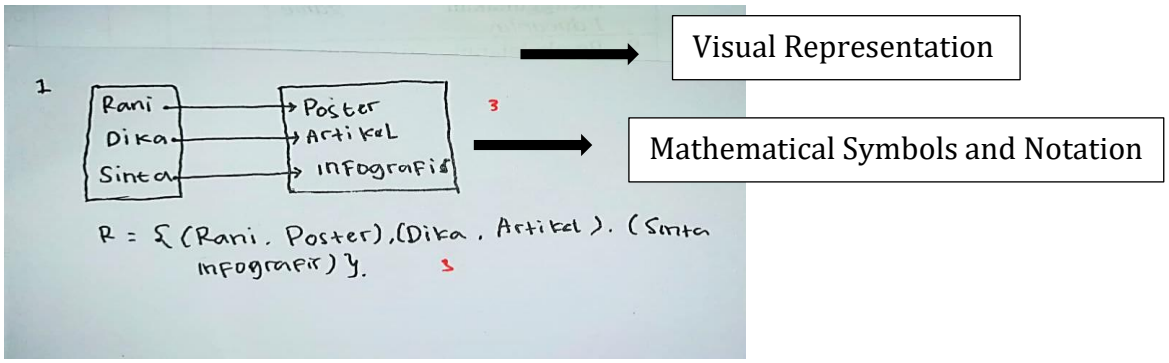

Figure 3. Student 1's Pre-test Response

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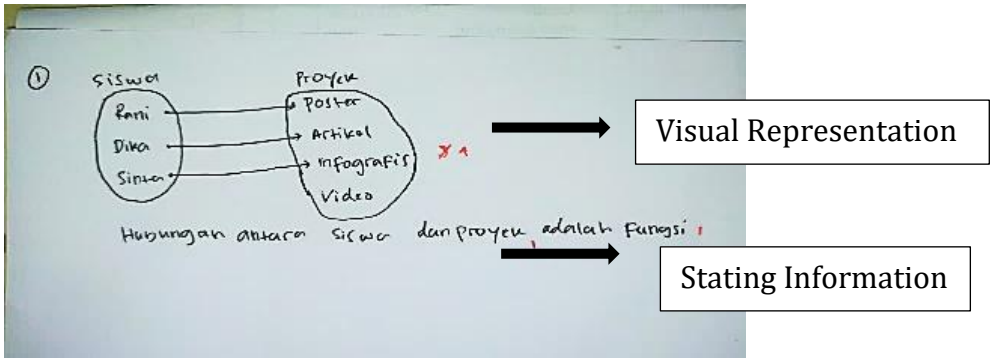

Figure 4. Student 2's Pre-test Response

Based on Figure 3, the student demonstrated a basic understanding of the given problem. This is indicated by the ability to use mathematical symbols by identifying sets A and B and presenting an arrow diagram as a form of visual representation. However, the solution steps were not arranged in a coherent and systematic manner. The representation of relations and functions was also still inaccurate and was not supported by adequate written explanations reflecting the student's reasoning process. In Figure 4, the student presented a relatively more structured response compared to the previous example. Nevertheless, the expression of mathematical ideas through symbols, models, and notations was still not entirely accurate, resulting in the intended mathematical relationships not being clearly and precisely conveyed.

The overall pre-test results indicate that students' mathematical communication skills prior to the intervention were not yet optimal. Students were not able to: (1) construct solution procedures systematically, (2) present accurate visual representations, (3) clearly communicate mathematical relationships through symbols and written explanations, and (4) verify the obtained solutions. After the implementation of the Educaplay-based game learning media integrated with the CTL approach, an improvement in students' abilities was observed. Examples of students' post-test responses are presented in Figures 5 and 6.

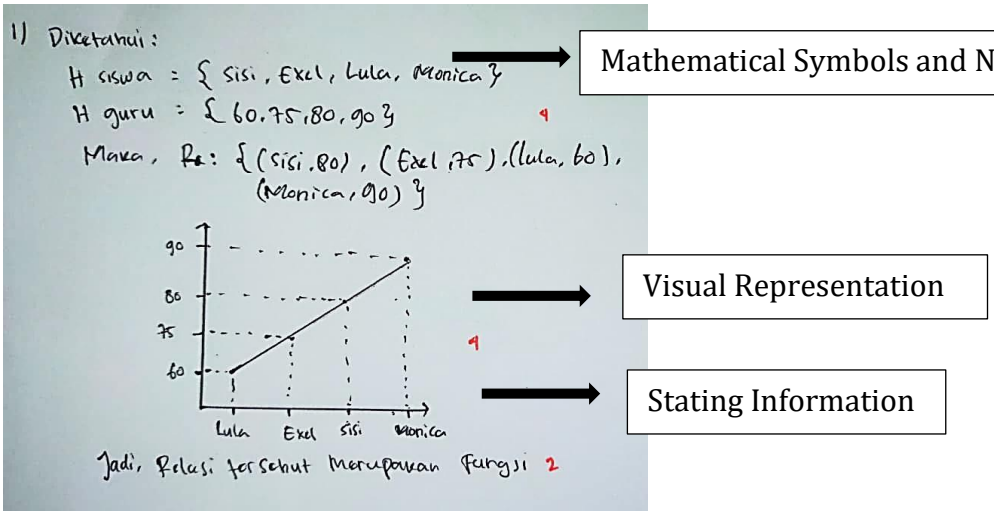

Figure 5. Student 1's Post-test Response

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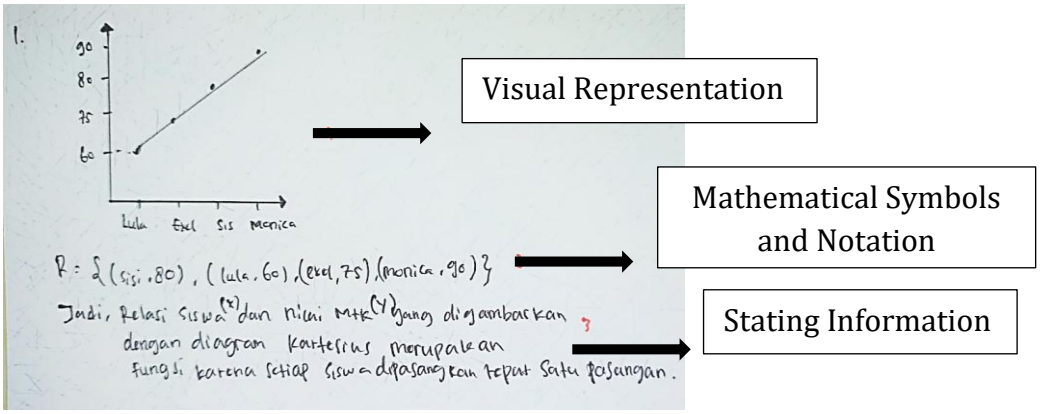

Figure 6. Student 2's Post-test Response

The Educaplay-based game learning media in Figure 5 and 6 used in this study was presented in the form of web-based interactive activities that integrate visual elements, text, and immediate responses. The Educaplay interface consists of a main page containing problem instructions, an interaction area (such as multiple-choice, drag-and-drop, or short-answer formats), and an automatic feedback feature that instantly displays whether students' answers are correct or incorrect. In addition, a real-time scoring feature is provided, allowing students to monitor their performance during the activity. The visual design is relatively simple yet engaging, utilizing colors, icons, and illustrations that support students' understanding of relations and functions concepts. Therefore, the Educaplay interface functions not only as an evaluation tool but also as an interactive practice medium that promotes active student engagement.

In Figure 5, Student 1 demonstrated a noticeable improvement. The student was able to present the known information more completely, including the sets of students and teachers, as well as the relation pairs in the form of ordered pairs. The graphical representation was also improved, with clearer axes and scales, and concluded with the identification that the relation represents a function. Although there were still some inconsistencies between the ordered pairs and the graph presented, and the arrangement of data on the horizontal axis was not entirely systematic, overall the response was more structured and the use of mathematical symbols was more accurate compared to the initial stage.

In Figure 6, Student 2 demonstrated a more optimal improvement. The student was able to represent the data accurately in the form of an appropriate graph and then express it in complete and consistent ordered pairs. In addition, the conclusion provided was clear and logically structured. This response indicates that the student not only understood the concepts of relations and functions but was also able to communicate mathematical ideas through various forms of representation, including graphs, ordered pairs, and systematic written explanations. This finding suggests an improvement in students' mathematical communication skills after the implementation of the Educaplay-based game learning media integrated with the CTL approach.

The improvement observed across each indicator of mathematical communication skills indicates that the developed media made a positive contribution to the learning process. This finding is consistent with the view of

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Kemp and Dayton (1985), who state that instructional media can enhance motivation, attract attention, and create an enjoyable learning environment. From the perspective of Skinner's behaviorist theory, features such as scoring, immediate feedback, and repeated practice in Educaplay function as reinforcement, which encourages active student engagement.

Furthermore, the principles of multimedia learning proposed by Mayer are reflected in the use of this media, as it integrates text, images, and interactive visual elements to support more effective conceptual understanding. This finding is also in line with the mathematical communication standards proposed by the NCTM, which emphasize the importance of providing students with opportunities to organize and communicate mathematical ideas through oral, written, and visual forms. The implementation of the CTL approach encourages students to relate mathematical concepts to real-life situations, thereby facilitating the process of explanation and reflection of understanding. Therefore, the interactivity of the media, reinforcement of learning, and the connection to real-life contexts serve as key factors contributing to the improvement of students' mathematical communication skills in Figure 7.

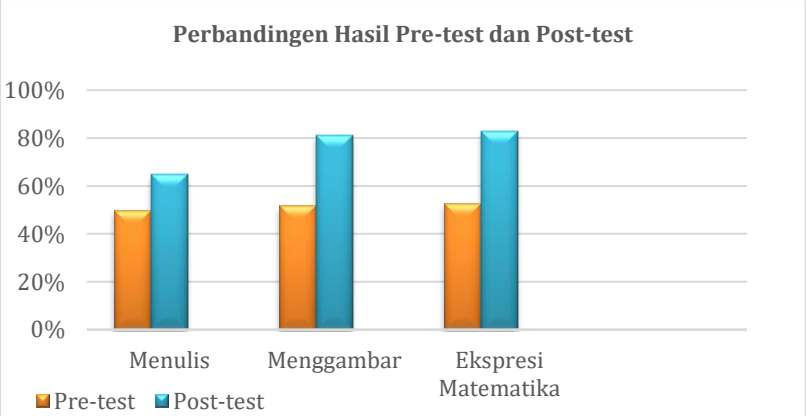

Figure 7. Comparison of Pre-test and Post-test Results

Based on Figure 7, there is an improvement in all indicators of students' mathematical communication skills. The most prominent increase occurs in the mathematical expression aspect, indicating that students have developed their ability to visualize concepts and use mathematical notation more accurately. Meanwhile, the writing aspect also shows improvement, but it is still in the moderate category.

The results indicate that although there is an improvement, students' mathematical writing skills have not yet reached an optimal level. This is due to the characteristics of the learning media, which place greater emphasis on quick responses, multiple-choice answers, and visual activities rather than exploratory and written elaboration tasks. As a result, students have not been given sufficient opportunities to develop their ability to construct mathematical arguments in a systematic and in-depth manner. Therefore, supporting activities are needed, such as essay-based exercises, reflective discussions, and reasoning-based assignments, to strengthen students' written communication skills.

Next, the students' pre-test and post-test results were analyzed using the N-Gain method to determine the level of improvement in mathematical communication skills in a more measurable way.

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Table 2. N-Gain Analysis Results

Category	N	Mean	N-Gain Score
Pre-test	28	51,92	0,56
Post-test	28	76,82	

Based on Table 2, the average pre-test score of 51.92 increased to 76.82 in the post-test, with a total of 28 students as respondents. The N-Gain value obtained was 0.56, which falls into the moderate category. This indicates that the use of Educaplay game-based learning media with a Contextual Teaching and Learning (CTL) approach is fairly effective in improving students' mathematical communication skills, although the improvement has not yet reached a high category.

However, the effectiveness achieved has not yet reached an optimal level. Several factors contribute to this, including limited time in using the learning media, students' ongoing adaptation to digital learning models, and differences in their prior abilities. In addition, learning success is also influenced by the extent to which the learning media is integrated with students' existing cognitive structures (Ausubel, 1968). If this connection is not optimally established, the understanding gained by students will also not be maximized.

In addition, exploratory-based learning such as Educaplay has the potential to increase student engagement; however, it may also impose additional cognitive load if it is not supported by adequate scaffolding (Clark, 1983). Therefore, further development is needed, such as optimizing the duration of media use, improving the quality of instructional guidance, and increasing the number of respondents so that the research findings become more representative.

Conclusion and Suggestion

Based on the results of the research and discussion, it can be concluded that the use of Educaplay game-based learning media with a Contextual Teaching and Learning (CTL) approach is able to improve students' mathematical communication skills, with an N-Gain value of 0.56, which falls into the moderate category. This improvement indicates that the developed media is fairly effective, particularly in the aspects of visualization and mathematical expression.

However, this study still has several limitations, such as the relatively short duration of media use, the limited number of respondents, and the suboptimal development of students' written communication skills. Therefore, future research is recommended to develop more interactive and adaptive learning media, expand the sample size, and integrate reasoning-based exercises to improve mathematical communication skills in a more comprehensive manner.

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