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Submission date: 16-Oct-2023 05:38AM (UTC-0700)
Submission ID: 2190174169
File name: ematical_Communication_and_Self_Regulated_Learning_Skills-1.docx (207.87K)
Word count: 7574
Character count: 47561

Jurnal Analisa xx (1) (20xx) 60-72
http://journal.uinsgd.ac.id/index.php/analisa/index
p-ISSN : 2549-5135 e-ISSN : 2549-5143

Development of Interactive Learning Media Through the Problem Based Learning Model to Improve Students' Mathematical Communication and Self Regulated Learning Skills

Mariani Sitanggang[1], Mulyonor[2], Sahat Saragih[3]

Postpraduate Mathematics Education Study Program, Medan State University
*marianistg26@gmail.com

Abstrak

Penelitian ini bertujuan untuk (1) menghasilkan media pembelajaran interaktif berbasis model Problem Based Learning yang valid, (2) praktis, dan (3) efektif. Penelitian, (4) menganalisis peningkatan kemampuan komunikasi matematis siswa dengan menggunakan media pembelajaran interaktif dengan model Problem Based Learning, (5) menganalisis peningkatan kemampuan self-regulated learning siswa, dan (6) menganalisis proses jawaban yang digunakan oleh siswa. siswa untuk menyelesaikan tes kemampuan komunikasi matematis. Model 4D Thiagarajan, Semmel, dan Semmel (Define, Design, Develop, Disseminate) digunakan dalam penelitian pengembangan ini. Penelitian ini melibatkan siswa kelas VIII SMP N 1 Bandar. Media pembelajaran interaktif berupa RPP, LKS, penilaian komunikasi matematis, dan angket self-regulated learning merupakan hasil penelitian. Hasil penelitian menunjukkan bahwa (1) media pembelajaran interaktif yang dikembangkan melalui model Problem Based Learning valid pada uji coba II, (2) diperoleh praktik pada uji coba II, dan (3) efektif pada uji coba II. Pada uji coba II, media pembelajaran interaktif melalui model Problem Based Learning meningkatkan kemampuan komunikasi matematis siswa. Peningkatan diri siswa—pembelajaran yang dikontrol media. Pada uji coba II pembelajaran interaktif dengan menggunakan model Problem Based Learning mengalami peningkatan. (6) Siswa biasanya melakukan kesalahan konsep, operasi perhitungan dan prinsip ketika menjawab tes kemampuan komunikasi matematis. Menurut penelitian, guru dapat menggunakan perangkat pembelajaran ini untuk meningkatkan kemampuan komunikasi matematis siswa.
Kata kunci: *kemampuan komunikasi matematis, model Problem Based Learning, self regulated learning.*

Abstract

This research aims to (1) produce interactive learning media based on the Problem Based Learning model that is valid, (2) practical, and (3) effective. Research, (4) analyzes the increase in students' mathematical communication skills using interactive learning media with the Problem Based Learning model, (5) analyzes the increase in students' self-regulated learning abilities, and (6) analyzes the answer process used by students. students to complete a mathematical communication ability test. The Thiagarajan, Semmel, and Semmel 4D models (Define, Design, Develop, Disseminate) were used in this development research. This research involved class VIII students of SMP N 1 Bandar. Interactive learning media in the form of lesson plans, worksheets, mathematical communication assessments, and self-regulated learning questionnaires are the results of research. The research results showed that (1) the interactive learning media developed through the Problem Based Learning model was valid in trial II, (2) practice was obtained in trial II, and (3) it was effective in trial II. In trial II, interactive learning media through the Problem Based Learning model improved students' mathematical communication skills. Student self-improvement—media-controlled learning. In trial II, interactive learning using the Problem Based Learning model experienced an increase. (6) Students usually make errors in concepts, calculation operations and principles when answering mathematical communication ability tests. According to research, teachers can use this learning tool to improve students' mathematical communication skills..
Keywords: *mathematical communication skills, Problem Based Learning model, self regulated learning*

1. INTRODUCTION

The acquisition of mathematical communication skills is an essential endeavor for students to undertake in order to achieve proficiency in the study of mathematics. This aligns with the stipulations set forth in Minister of National Education Regulation No. 22 of 2006, wherein it elucidates that the primary objective of mathematics education is to equip students with the ability to effectively articulate concepts through the utilization of symbols, tables, diagrams, or other forms of media, thereby facilitating the elucidation of complex scenarios or predicaments. This aligns with the principles set forth by the esteemed National Council of Teacher Mathematics (NCTM), which posits that a fundamental objective of mathematical education is the acquisition of skills in effectively conveying mathematical concepts and ideas (Ariani, 2017). In accordance with the scholarly investigation conducted by Rahmi, Nadia, Hasibah, and Hidayat (2017), it is evident that the acquisition of mathematical communication skills stands as a crucial component within the repertoire of mathematical abilities that students ought to possess.

The significance of possessing proficient mathematical communication skills lies in its capacity to bolster and fortify other mathematical proficiencies. Put simply, the ability to effectively communicate mathematically is an essential prerequisite for students to successfully navigate and resolve complex problems. This means that if students cannot communicate well to understand mathematical problems or concepts then they cannot solve problems well. The utilization of mathematical symbols and formulas constitutes an integral facet of the aptitude for mathematical discourse. This assertion is corroborated by Ansari (2016), who posits that the cultivation of mathematical communication skills in students holds significant import for several reasons. Firstly, it enables individuals to adeptly depict and expound upon situations or circumstances through written or verbal means, as well as through graphical representations, pictorial depictions, or algebraic formulations. Secondly, the act of engaging in mathematical communication serves to elucidate and refine one's cogitation pertaining to mathematical concepts across diverse contexts. Thirdly, it fosters the development of a comprehensive comprehension of mathematical ideas, such as the pivotal role played by definitions within the realm of mathematics. Fourthly, it empowers individuals to employ their skills in writing, reading, and listening to effectively interpret and evaluate mathematical notions. Fifthly, it facilitates the critical examination of mathematical ideas, thereby promoting a deeper understanding of their intricacies. Lastly, it engenders an appreciation for the value of notation and underscores the integral role of mathematics in the evolution and refinement of ideas.

Furthermore, it has been substantiated through meticulous research conducted by Yusra and Saragih (2016) that mathematical communication skills encompass the aptitude to articulate mathematical notions utilizing symbols, tables, diagrams, or other forms of media. This proficiency serves to elucidate mathematical predicaments and effectively communicate them through the application of mathematical language during the pedagogical process. Consequently, this invaluable skillset aids educators in comprehending students' capacity to interpret and articulate their comprehension of mathematical concepts and procedures that they are actively acquiring.

Nevertheless, it is imperative to acknowledge that the level of anticipation one holds is inherently linked to the degree of correspondence it bears with actuality. The proficiency in mathematical communication skills remains at a suboptimal level. Students with limited proficiency in mathematical communication may pose challenges for their peers in comprehending the presented inquiries, whereas students endowed with strong communication abilities can readily undertake the necessary measures to unravel a given problem. This phenomenon is evident in the scholarly work of Sari, as documented in Fitriyanti's publication in 2021. Sari's research posits that when students are presented with questions that deviate from the exemplars covered in their instruction, they encounter challenges in effectively addressing these inquiries. This difficulty arises from their lack of a clear starting point, impeding their ability to successfully navigate and resolve the given questions. This assertion was further substantiated by scholars through the administration of inquiries to a cohort of 30 students enrolled in the eighth-grade class denoted as VIII-2 at SMP Negeri 1 Bandar, focusing on the subject matter pertaining to Cubes and Blocks. The ensuing discourse pertains to the acquisition and refinement of mathematical communication proficiencies.

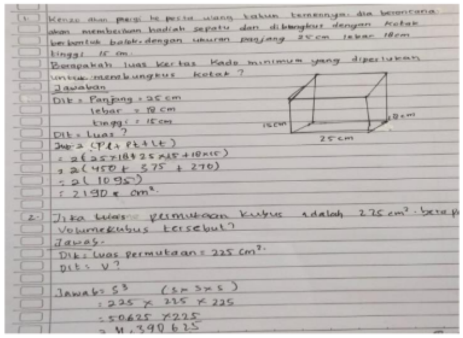

Figure 1. Answer Sheet from One of the Students

Based on the elucidation provided regarding the responses to the inquiries pertaining to communication skills, it becomes evident that the students possess a deficiency in comprehending the issue at hand. This deficiency is manifested in their ability to generate written notions for mathematical predicaments, yet they falter in accurately formulating a coherent sequence of steps to resolve said predicament. Furthermore, the students exhibit an incapacity to construct a mathematical framework that adequately represents the problem in question. Furthermore, it is worth noting that students exhibit a diminished level of meticulousness, thereby resulting in a propensity for errors when attempting to solve various inquiries. Consequently, in the event that the formulation of the solution is erroneous, it follows that the resultant answer will likewise be incorrect. In order to facilitate the problem-solving process, it is advisable for students to initially substitute every numerical value within the given problem with a variable, letter, or symbol. This substitution technique serves to simplify the subsequent steps involved in tackling the problem. Based on the responses provided by the students, one may deduce that there exists a deficiency in the students' aptitude for mathematical communication. This aligns with the findings of Lestari, Saragih, and Hasrat (2018), who assert that deficiencies in mathematical communication skills among students manifest in their inability to effectively conceptualize and articulate mathematical models, as well as their incapacity to furnish coherent written justifications for their conclusions.

This phenomenon may be attributed to the imprecise choice of pedagogical models and instructional media employed during the mathematics education process. It is widely acknowledged that educators persist in employing direct instructional methods, specifically adhering to the traditional lecture-based model, thereby resulting in diminished levels of learner engagement. Hence, in instances where an instructor presents inquiries that deviate from the illustrative questions expounded upon, students' capacity to engage with said questions is diminished.
It is imperative for students to possess a repertoire of cognitive, affective, and psychomotor abilities in order to thrive academically and holistically. In the contemporary realm of education, it is imperative to acknowledge that affective capacities hold equal significance to cognitive and psychomotor proficiencies. Self-regulated learning is an indispensable facet within the realm of affective domains that holds paramount significance for students.

In light of this matter, drawing upon the scholarly investigation conducted by Yandari et al. (2018), it becomes evident that self-regulated learning assumes a paramount role in the process of acquiring knowledge and skills. Self-regulated learning encompasses the cognitive aptitude to autonomously govern one's cognitive processes and behavioral actions, thereby obviating the need for external emotional reliance on others. In a similar vein, Schunk and Zimmerman (as cited in Zamnah, 2017) posit that self-regulated learning (SRL) is an intricate cognitive endeavor wherein individuals engage in a multifaceted interplay of introspective cognition, affective states, strategic planning, and behavioral actions, all meticulously directed towards the attainment of desired objectives. According to the scholarly work conducted by Pratama, Minarni, and Saragih (2017), it elucidates the imperative nature and exigency of independent learning within the contemporary educational landscape. Therefore, it can be deduced that self-regulated learning pertains to an individual's disposition towards a particular matter, wherein said person exercises autonomy devoid of external influences.

The diminished level of student self-regulated learning can be attributed to the inseparability of this phenomenon from the educational framework implemented within the school environment. One of them is subject to the influence of inadequate pedagogical frameworks and media platforms. In line with the learning model, the majority of teachers in schools have not implemented learning models and media that involve student activities, so the majority of teaching teachers apply conventional learning.

Indeed, individuals who possess commendable self-regulatory aptitude in the realm of learning exhibit a remarkable capacity to confront and surmount various challenges. Such individuals, emancipated from the shackles of external reliance, are endowed with the autonomy to exercise discernment and make informed choices that shape the trajectory of their existence. This aligns with the scholarly findings of Mahmoodi, Kalantari, and Ghaslani (2014), who expound upon the notion that students who exhibit a greater propensity for employing adaptive self-regulatory strategies tend to exhibit superior learning outcomes. This implies that students who exhibit a higher degree of autonomous agency tend to manifest superior cognitive acquisition. Hence, one can assert that the autonomy inherent in a student's disposition serves to bolster their cognitive aptitude. Henceforth, the cultivation of self-reliance necessitates enhancement.

In accordance with the educational maxim espoused by Mr. Ki Hajar Dewantara, it is posited that the efficacy of the learning system hinges upon the comportment of the educator. Based on my empirical observations as a diligent researcher, it is evident that the deficiency in mathematical communication and self-regulated learning skills among students can be attributed to the pedagogical choices made by the teacher in designing the mathematics learning scenarios. It is posited that the attainment of success may be contingent upon the capacity of the given circumstances to ameliorate the prevailing condition. One of the endeavors undertaken to ameliorate this circumstance entails the development of efficacious pedagogical approaches, specifically the integration of interactive media in conjunction with innovative instructional frameworks, thereby fostering the enhancement of students' mathematical communication and self-regulated learning proficiencies.

Interactive learning media refers to a form of educational media that seamlessly integrates various elements such as written text, auditory cues, dynamic visuals, and audiovisual content. Its primary objective is to enhance and streamline the process of acquiring knowledge and skills. The utilization of interactive learning media within the educational sphere yields numerous advantageous outcomes. The utilization of interactive learning media exerts a profound impact on the enhancement of educational standards. The utilization of interactive learning media as an educational resource constitutes a strategic approach to the process of acquiring knowledge. This aligns with the findings of Surya's research (Kamarullah, 2017), which posits that the process of acquiring mathematical knowledge necessitates the utilization of engaging and enjoyable pedagogical approaches in order to effectively attain educational goals.

The aforementioned statement underscores the imperative for educators to possess optimal duties and responsibilities in order to effectively facilitate learning endeavors that are distinguished by heightened student engagement. When student engagement reaches a heightened level, it fosters a propitious environment for meaningful learning interactions to transpire, thereby enhancing the efficacy of teaching and learning endeavors. Notwithstanding the active engagement of educators, it is imperative to acknowledge that students too exhibit a commendable level of dynamism in their pursuit of knowledge acquisition. Henceforth, by fostering a climate of heightened student engagement, it is anticipated that their aptitude for mathematical discourse shall be significantly augmented.

The aforementioned statement is congruent with the viewpoint expressed by Djamarah (Batubara, 2017: 15), wherein it is posited that a pivotal determinant in shaping the educational journey of students lies in the existence of instructional materials. The utilization of interactive learning media significantly facilitates the comprehension of abstract concepts among students who find themselves in the concrete operational phase. Furthermore, it is anticipated that the incorporation of interactive educational media will serve as a valuable adjunct to facilitate student learning. The advent of learning media assistance has effectively shifted the paradigm of education away from traditional teacher-centered learning, thereby empowering students to take a more active role in their own educational journey. Students possess the inherent liberty to acquire knowledge and cultivate their aptitudes, particularly in the realm of mathematical discourse. The manifestation of self-regulated learning serves as a clear indication that the pedagogical approach of student-centered learning is being effectively implemented. Within the realm of self-regulated learning, students assume the role of subjects, wielding control, making decisions, and taking initiative in the pursuit of their own educational endeavors. Hence, the capacity to govern or steer one's own acquisition of knowledge stands as the primary prerequisite.

The implementation of interactive educational media supported by Adobe Flash CS6 holds significant utility in fostering autonomous learning among students. This innovative approach enables students to engage in self-regulated learning, liberating them from the need for direct instruction by their teachers. By affording students the opportunity to revisit and review materials at their own pace, they can persistently engage with challenging concepts until a comprehensive understanding is achieved. In addition to that, the instructional material is also presented in an interactive manner, wherein students are guided directly by the program in the execution of the educational process. Hence, the utilization of Adobe Flash CS6 media by students in independent study endeavors has the potential to foster heightened levels of student engagement, thereby facilitating the development and enhancement of their mathematical communication proficiencies. The utilization of interactive educational media through the utilization of Adobe Flash CS6 would undoubtedly be rendered more captivating if it were to be implemented in conjunction with a pedagogical framework that encourages students to engage in active learning. Hence, in order to optimize the efficacy of classroom instruction through the utilization of interactive learning media, thereby fostering active student engagement in the educational endeavor, it becomes imperative for educators to meticulously select and adeptly implement an optimal pedagogical framework. One pedagogical framework that is deemed suitable to employ in this particular quandary is the Problem Based Learning (PBL) model.

The problem-based learning model is a pedagogical framework that empowers students to discern and identify challenges within intricate contexts. Within this particular framework, students engage in a collective effort, working together in groups, to discern and ascertain the essential components required for acquiring knowledge and effectively resolving complex challenges. The challenges inherent in the utilization of the problem-based learning model pertain to quandaries that are intricately intertwined with the fabric of our quotidian existence. Consequently, the problem-based learning model emerges as a fitting pedagogical approach for the facilitation of mathematical comprehension.

Problem Based Learning (PBL) is an instructional approach that necessitates the active engagement of students in various learning endeavors. According to the scholarly investigation conducted by Saragih et al. (2018), it has been posited that the Problem-Based Learning Model (PBM) represents an innovative pedagogical approach that centers around the student, thereby fostering an environment conducive to active engagement and creative thinking. The aforementioned statement elucidates that the Problem Based Learning (PBM) model serves as a pedagogical approach that prioritizes the learner, fostering an environment conducive to active engagement and the cultivation of creativity. Sungur and Tekkaya's (2018) study corroborates the notion that the problem-based learning model confers a distinct advantage to students in various cognitive domains. Specifically, students who engage with this pedagogical approach exhibit heightened learning goal orientation, task value, elaboration of learning strategies, critical thinking skills, and metacognitive regulation, in stark contrast to their counterparts who do not partake in problem-based learning. In order to imbue a sense of dynamism within the educational journey, the incorporation of interactive learning media necessitates the integration of the problem-based learning model. Moreover, the scholarly inquiry undertaken by Ningrum (2016) pertaining to problem-based learning serves as an instructive paradigm that may serve as a conduit for the enhancement of students' aptitude in the realm of mathematical communication.

In addition to its capacity for enhancing students' aptitude in mathematical discourse, the utilization of the problem-based learning (PBL) framework in conjunction with interactive instructional media also serves as an educational model that fosters the cultivation of self-regulated learning dispositions among students. The findings of the study conducted by Aulia, et al (2018) have elucidated that the utilization of Edmodo as a pedagogical tool in the educational realm exhibits a propensity to enhance students' self-reliance in the acquisition of knowledge, particularly when employing the problem-based learning approach. In accordance with the aforementioned study, the research findings put forth by Handayani and Wahyuni (2021) have deduced that the utilization of the problem-based learning approach, supplemented by the Edmodo platform, in students' self-regulated learning endeavors, has yielded superior academic outcomes in comparison to the employment of conventional instructional methodologies.

The primary objective of cultivating interactive educational media via the Problem Based Learning (PBL) framework is to generate a tool that can effectively facilitate students' learning experiences within the classroom. This entails a shift from a didactic approach, where students passively receive information, to an active engagement where students actively seek knowledge. Furthermore, the assessment process is transformed from a focus on mere output to a more comprehensive evaluation of the learning process itself. By adhering to these principles, the resultant product can effectively fulfill the desired educational objectives, particularly in enhancing students' abilities in mathematical communication and self-regulated learning.

Given the aforementioned exposition and the issues elucidating the inadequacy of the existing learning materials, as well as the students' subpar aptitude in mathematical communication and self-regulated learning, it is anticipated that the creation of interactive mathematics learning media utilizing the problem-based learning paradigm will serve to enhance the students' mathematical and self-regulated communication proficiencies. The impetus behind the author's decision to embark on a research endeavor is encapsulated within the title: "Development of Interactive Learning Media Through Problem Based Learning Models to Enhance Students' Proficiency in Mathematical Communication and Foster Self-Regulated Learning Abilities."

2. METHOD

The problem formulation and study aims classify this research as development research using the Thiagarajan, Semmel, and Semmel 4-D model. Interactive learning media and tools were developed in this project. This research produces valid, practical, and successful interactive learning media using the Problem Based Learning model and all learning media and research instruments needed to develop it.

Building Flat Side Rooms (Cubes and Blocks) was the topic of this class VIII odd semester 2022/2023 research at SMP N 1 Bandar. Because SMP N 1 Bandar had never conducted research on interactive learning media based on the Problem Based Learning learning paradigm on Building Flat Side Spaces (Cubes and Blocks), this study location was chosen. This research involved 30 Class VIII students from SMP N 1 Bandar in 2022/2023 using interactive learning media using the Problem Based Learning model and Building Data Side Spaces (Cubes and Blocks) material.

The 4D model has four stages: definition, design, development, and dissemination. This study covers definition, design, development, and restricted dissemination. Due to funding, time, and research staff constraints, dissemination was limited. The research development model is schematically represented in Figure 2. Here are the learning media development stages.:

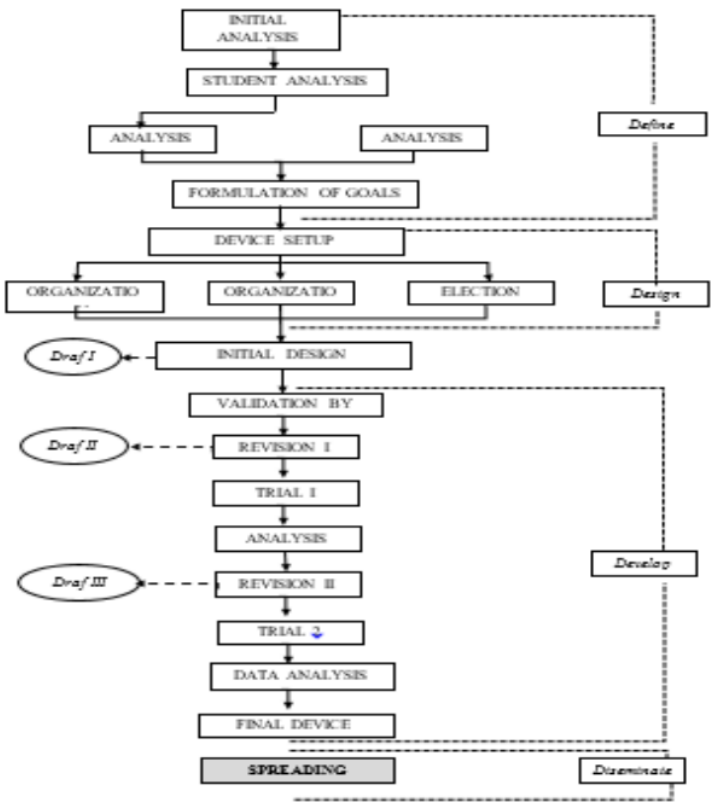

Figure 2. 4D Model Learning Media Development Chart

3. RESULT AND DISCUSSION

The output of the definition and design processes is an initial blueprint for a teaching instrument that will be referred to as draft I. The first step in validating draft I with specialists and then conducting field tests is the first phase of the development of the results. The structure, subject matter, graphics, and language of the newly designed learning tools are the primary areas of focus during expert validation. It is on the basis of the results of expert validation that revisions and improvements are made to the learning tools that have been developed. These results come in the form of validation scores, corrections, criticism, and suggestions. The outcomes of the validation that was performed on the various learning tools will be described in the following.

Table 1. Recapitulation of Validation Results

No	The object being assessed	Average total validation value	Validation Level
1.	Learning Implementation Plan	4,36	Valid
2.	Student Worksheet	4,32	Valid
3.	Interactive Learning Media	4,65	Valid
4.	Communication Skills	4,42	Valid
5.	Self Regulated Learning	4,35	Valid

According to the data presented in Table 1, the overall average for each type of learning equipment falls somewhere in the range 4–5 with the valid category. According to the validity criteria, it is possible to assert that the newly designed educational module satisfies the valid criteria.

Analysis of the Achievement of Classical Mathematical Communication Skills Trial I

A test of students' mathematical communication abilities was used in this study to determine the level of student mastery. The level of student mastery was determined based on the students' mathematical communication abilities. The purpose of this test, which is administered both before and after learning takes place, is to determine the extent to which students have mastered the material they have studied and whether or not their knowledge is comprehensive. Therefore, the findings of this test will be used as assessment material for researchers so that they can make improvements to items that need to be done in a later second field study. In the next table, table 2, you will find a description of the outcomes of the students' mathematical communication skills during the trial I.

Table 2. Description of Results of Students' Mathematical Communication Skills in Trial I

Information	Pretest of Students' Mathematical Communication Ability	Posttest of Students' Mathematical Communication Ability
The highest score	79,17	89,58
Lowest Value	33,33	54,17
Average	49,93	75,90

According to Table 2, it can be shown that the students' average mathematical communication skill increased to 75.90 points after completing the posttest, up from 49.93 points in the pretest findings. In addition, the amount of mathematical communication expertise possessed by students as measured by the posttest findings of trial I is presented in the following table, which may be found below.

Table 3. Level of Mathematical Communication Mastery of Trial I Students

No	Value Interval	Pretest		Postest		Category
		The number of students	Percentage	The numbe	Percentage	
1	$0 \leq KKM < 60$	22	73,33%	1	3,33%	Very low
2	$60 \leq KKM < 70$	5	16,67%	8	26,67%	Low
3	$70 \leq KKM < 80$	3	10%	10	33,33%	Currently
4	$80 \leq KKM < 90$	-	-	11	36,67%	Tall
5	$90 \leq KKM \leq 100$	-	-	-	-	Very high

Table 3 shows that in the pretest, 22 students (73.33%) had very low mathematical communication skills, 5 (16.67%) had low, 3 (10%) had medium, and 0 (0%) had high. 0% of pupils have very high mathematical communication skills. However, in the posttest, the results showed that 1 student (3.33%) had a mastery level of mathematical communication skills in the very low category, 8 students (26.67%) had a mastery level of mathematical communication skills in the low category, 10 students (33, 33%) have a level of mastery of students' mathematical communication skills in the medium category, 11 students (36.67%) have a level of mastery of students' mathematical communication skills in the high category, while the level of mastery of students' mathematical communication skills in the very high category is none or 0 students (0%). Table 4 shows student self-regulated learning questionnaire findings.:

Table 4. Students' Self-Regulated Learning in Trial I

Category	The number of students	Percentage (%)
Very high	2	6,67
Tall	16	53,33
Low	8	26,67
Very low	4	12,33
Total	**30**	**100**

According to Table 4, the number of students who received the very high category was 2 out of 30 students (6.67%), while the number of students who received the high category was 16 out of 30 students (53.33%). Table 4 also shows that the number of students who received the low category was 8 out of 30 students (26.67%), while the number of students who received the very low category was as many as 4 out of 30 students (12.33%).

Analysis of the Achievement of Classical Mathematical Communication Skills Trial II

A description of the results of students' mathematical communication skills in trial II is shown in Table 5 below:

Table 5. Descriptions of Results of Students' Mathematical Communication Ability Experiment II

Information	Pretest of Students' Mathematical Communication Ability	Posttest of Students' Mathematical Communication Ability
The highest score	89,58	95,83
Lowest Value	54,17	64,58
Average	75,90	87,63%

According to the data presented in Table 5, it is evident that the mean mathematical communication proficiency of students during posttest 1 was recorded as 75.90, while during posttest 2, it exhibited an increase to 87.63. Moreover, the assessment of students' proficiency in mathematical communication skills during the second trial can be observed in Table 6 presented subsequently.

Table 6. Level of Mathematical Communication Mastery of Trial II Students

No	Value Interval	Pretest		Postest		Category
		The number of students	Percentage	The numbe	Percentage	
1	0 ≤ KKM < 60	1	3,33%	-	-	Very low
2	60 ≤ KKM < 70	8	26,67%	3	10%	Low

3	70 ≤ KKM < 80	10	33,33%	2	6,67%	Currently
4	80 ≤ KKM < 90	11	36,67%	8	26,67%	Tall
5	90 ≤ KKM ≤ 100	-	-	17	56,66%	Very high

Based on the data presented in Table 6, it is evident that the posttest I results indicate varying levels of mastery in students' mathematical communication skills. Specifically, a mere 3.33% of students demonstrated a level of mastery categorized as "very low." In contrast, 26.67% of students exhibited a level of mastery classified as "low." Furthermore, 33.33% of individuals displayed a level of mastery categorized as "medium," while 36.67% of students showcased a level of mastery classified as "high." It is worth noting that none of the students reached the pinnacle of mastery, as the "very high" category remained unattained. The current student population is at a negligible percentage, specifically at 0%. However, the findings from posttest II revealed that there was a complete absence (0%) of students who demonstrated a minimal level of proficiency in the domain of mathematical communication skills. Conversely, a small fraction of the student population, specifically 3 individuals (10%), exhibited a modest level of mastery in this area. Additionally, a slightly larger proportion of the students, comprising 2 individuals (6.67%), demonstrated a moderate level of proficiency in their mathematical communication skills. On the other hand, a notable number of students, totaling 8 individuals (26.67%), showcased a commendable level of mastery in this domain. Finally, the majority of the student cohort, encompassing 17 individuals (56.66%), exhibited an exceptional level of proficiency in their mathematical communication skills, placing them in the highest category of mastery. The aforementioned text, consisting of a mere three characters, appears to lack any discernible intellectual The tabulated data pertaining to the outcomes of the student self-regulated learning questionnaire are readily observable within Table 7.

Table 7. Student Self Regulated Learning in Trial II

Category	The number of students	Percentage (%)
Very high	5	**16,67**
Tall	15	**50,00**
Low	7	**23,33**
Very low	3	**10,00**
Total	**30**	**100**

According to the data presented in Table 7, it is evident that a mere 16.67% of the total student population, specifically 5 out of 30 students, achieved the esteemed distinction of falling within the very high category. In contrast, a significantly larger proportion of 50.00%, or 15 students out of the same cohort of 30, attained the high category. Furthermore, the low category was occupied by 7 students out of the total 30, accounting for 23.33% of the population. Lastly, a modest 10.00% of the student body, equating to 3 individuals out of the 30, found themselves classified within the very low category.

DISCUSSION

According to the findings of the posttest that were discussed earlier, the percentage of students who achieved a classical level of proficiency in their mathematical communication abilities during trial I was 73.33%, however after trial II, this number increased to 90%. The students' mathematical communication skills received from the results of trial I did not satisfy the criteria for classical achievement (>80%), but the students' mathematical communication skills gained from the results of trial II did fulfill the criteria for classical achievement. If we look at the results of classical achievement, we can see that.

According to the findings of the study presented earlier, the effectiveness requirements are satisfied when students' classical mathematical communication abilities are achieved with interactive learning media by using the problem-based learning model that was established. Tanjung and Nababan (2018) came to the conclusion that the learning media generated utilizing problem-based learning satisfies the effective requirements evidenced by the students' individual and classical learning completeness. This finding lends credence to the findings of Tanjung and Nababan (2018). According to the findings of Rahayu's research (2019), which came to the conclusion that the learning medium generated based on Problem-Based Learning met the effective criteria as demonstrated by the attainment of classical abilities exceeding 80%, this is in line with the aforementioned statement.

The content and problems in the LKPD, which are produced in accordance with the conditions of the student's learning environment and refer to problem based learning methods, are largely responsible for the comprehensive nature of the student's educational experience. Students will develop an interest in learning as well as an active involvement in the learning process and in the problem-solving process if problem-based learning tools are utilized in the classroom. Students are able to create their own information and draw conclusions based on the knowledge they have obtained if professors or friends provide them with advice and instructions in the form of leading questions.

This is supported by Vygotsky's viewpoint, which asserts that intellectual development takes place when individuals are exposed to novel and difficult situations and when they make an effort to find solutions to the issues that these experiences provide to them. Individuals make an effort to construct new understanding by first linking newly acquired information with the foundational information they already possess, with the goal of better comprehending the subject matter.

Vygotsky proposed that pupils' knowledge would be constructed by their experiences and the environment in which they were immersed. During this experience, individuals generate new meaning by connecting new knowledge with prior knowledge and drawing connections between the two. In accordance with Bruner's ideas concerning the Problem-Based Learning model, namely the concept of scaffolding. Bruner defines the process of scaffolding as one in which pupils are assisted in resolving a particular problem that is beyond the student's developmental capabilities with the assistance (scaffolding) of teachers, friends, or persons who are more knowledgeable than the student. Students will be more engaged in handling their learning activities if their teachers provide aid (scaffolding) in the early stages of learning and while they are completing their assignments. This will result in more effective learning and have an impact on the completion of classical learning.

It would indicate, on the basis of research findings as well as support from earlier research and learning theories, that interactive learning media designed based on the Problem Based Learning model can assist students in achieving classical achievements. Therefore, it is possible to draw the conclusion that the utilization of interactive learning media based on the proposed Problem-Based Learning model has satisfied the successful criteria in terms of traditional mathematical communication abilities.

4. CONCLUSION

A 4.65 average score indicates that the Problem Based Learning interactive learning media improved students' mathematics communication and self-regulated learning skills. Interactive learning material based on Problem-Based Learning meets practical standards. Based on: Expert/practitioner assessments say Problem-Based Learning methods can be used with few changes. In trial II, 89.37% of interactive learning material based on the Problem Based Learning model was implemented.

The Problem-Based Learning-based interactive learning media met the successful requirements. Based on: Trial II showed 90% classical student learning completion. Trial II met 83.39% of learning goals. 93.31% of students liked the interactive learning material and activities. Learning takes no longer than usual.

Using interactive learning media based on the Problem Based Learning learning model on flat-sided geometric material (cubes and blocks) increased students' mathematical communication skills from 75.90 to 87.63 and the N-gain value from 0.49 to 0.51 in the medium category. The average self-regulated learning of students utilizing interactive learning media based on the Problem Based Learning learning model on flat-sided geometric material (cubes and blocks) increased from 60.00 in trial I to 95.03 in trial II.

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