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Mathematical Writing Skills Reviewed from the Habits of Mind of Students in a Problem-Based Learning Model on Teaching at The Right Level Assisted by Liveworksheet

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Abstract

This study aims to analyze students' mathematical writing skills in terms of habits of mind through the implementation of the Teaching at the Right Level (TaRL)-based Problem Based Learning (PBL) model assisted by Liveworksheet. The research employed a mixed-methods approach with a sequential explanatory design, starting with quantitative data collection using a quasi-experimental posttest control design, followed by qualitative analysis. The participants were seventh-grade students at SMP Negeri 2 Sayung, selected through cluster random sampling and purposive sampling. The instruments included a mathematical writing skills test, a habit of mind questionnaire, observation sheets, interview guidelines, and documentation. The results indicate that the TaRL-based PBL model with Liveworksheet met the criteria for quality learning, with excellent implementation (average student engagement of 89.58%) and the achievement of learning mastery. The t-test (tcount = 3.658 > ttable = 1.670) and proportion difference test (zcount = 11.184 > ttable = 1.67) confirmed significant differences in mathematical writing skills between the experimental and control groups. Qualitative findings further revealed variations in achievement across different habits of mind categories. In conclusion, the TaRL-based PBL model assisted by Liveworksheet is effective in enhancing students' mathematical writing skills.

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INTRODUCTION

Mathematics education is part of the science cluster that plays an important role in honing students' intellectual abilities (Borasi & Rose, 1989; Mariamah, 2017). Through mathematics learning activities, students not only practice arithmetic but also develop thinking skills and the ability to apply basic concepts in various fields (Adrillian et al., 2024). One of the important objectives of mathematics learning is to train students to convey ideas through symbols, tables, diagrams, and other media to clarify problems (Siagian, 2016). This goal can be achieved if the learning process is effective and meets a number of prerequisites, including active student involvement, a variety of learning methods, motivation, a proportional curriculum, and careful planning (Lutfiyah & Sulisawati, 2019; Prabowo et al., 2022). The ability to express mathematical ideas in writing is known as mathematical writing skills (Gardenia, 2016).

Mathematical writing skills reflect the extent of students' understanding and can reveal their misconceptions (Puteri & Karlimah, 2018). Therefore, teachers need to assess this ability through both learning activities and written tests (Putria Nasution & Ahmad, 2018). The importance of mathematical writing is based on the role of mathematics as a language for conveying ideas concisely, clearly, and logically, as well as a means of interaction in the learning process (Tong et al., 2021). Unfortunately, PISA survey results show that the mathematical abilities of students in Indonesia are still relatively low, at levels 1–2 out of 6 levels, with an average score of 366 in 2022, far below the international average (Siregar et al., 2024).

Several studies have found that low mathematical writing skills are caused by a lack of student activity, a tendency toward passive learning, and the abstract nature of mathematics (Jusniani & Nurmasidah, 2021). Students still experience obstacles when they have to formulate problems, create mathematical models, or understand the interrelationships between concepts (Lestari & Effendi, 2022). Preliminary study results at SMP Negeri 2 Sayung also show that students are not yet able to accurately illustrate problems, making it difficult for them to determine the area of flat shapes. This condition shows that mathematics learning should not only focus on calculations but also develop reasoning, analysis, and the ability to express mathematical ideas in writing (Marasabessy, 2021).

Mathematical writing skills are closely related to habits of mind, which are thinking habits that help students plan strategies, solve problems, and expand their knowledge (Nurmeidina et al., 2025). Habits of mind do not arise naturally, but are formed through practice, discipline, and learning experiences based on real problems (Gardner et al., 2024). A number of studies show a positive relationship between mathematical writing skills and habits of mind (Rahmah et al., 2022).. Therefore, teachers are required to choose a learning model that can build students' mindsets and thinking habits, one of which is Problem Based Learning (PBL) (Suarditha et al., 2018).

Problem-Based Learning is a learning approach based on solving real problems by actively involving students, fostering cooperation, and encouraging communication skills (Yuberti et al., 2019). This model is in line with the concept of Teaching at the Right Level (TaRL), which is a learning strategy tailored to students' cognitive abilities, rather than simply based on age or grade level (Mustafa, Riana, et al., 2024). The integration of PBL and TaRL with the help of liveworksheet media allows students to learn more independently, explore their abilities through technology, and solve contextual problems more effectively (Astra et al., 2019; Septian et al., 2020). With this background, this study is titled "Mathematical Writing Skills Reviewed from the Habits of Mind of Students through the TaRL (Teaching at the Right Level)-Based Problem-Based Learning Model with the Help of Liveworksheets".

METHOD

The approach used in this study is a mixed methods research method. The type of mixed methods research used in this study is a sequential

explanatory model combination method. The first stage consists of quantitative data collection and analysis, followed by qualitative data collection and analysis in the second stage with the aim of strengthening the quantitative research results obtained in the first stage. The design used is a quasi-experimental design, which is research that approximates an experiment or pseudo-experiment with a posttest control design. The research procedures or steps in this study consist of a pre-research stage, research stage, and data analysis stage. The population in this study was seventh-grade students at SMP N 2 Sayung, consisting of 10 classes. At this level, students are of relatively the same age range, use the same curriculum, receive instruction at the same time, and are in the same grade level with class divisions not based on ranking. The sample used was taken using a random cluster sampling technique in the study by conducting a lottery from all seventh grade classes. Subject selection used a purposive sampling technique, with the consideration being to select students based on the grouping of the habits of mind questionnaire results, which had been categorized into three categories, namely proficient, developing, and apparent. The three criteria were then analyzed to find patterns of mathematical writing ability in terms of habits of mind.

The data collection techniques in this study included tests, interviews, observations, questionnaires, and documentation. The tests consisted of essay questions given to the experimental and control groups to measure mathematical writing skills, which had undergone validity, reliability, difficulty level, and discrimination tests. Interviews were conducted to obtain a description of students' mathematical writing skills in terms of habits of mind after learning, while observations were used to observe the learning process with the TaRL-based PBL model assisted by liveworksheets. Questionnaires were given to teachers and students to find out their assessment of the learning, while documentation in the form of students' work was used as supporting data. The research instruments used had undergone expert validation and testing, making them suitable for obtaining quantitative and qualitative data.

Data analysis was conducted quantitatively and qualitatively. Quantitative analysis included tests of normality, homogeneity, and similarity of means in the initial data, as well as hypothesis testing in the final data, which included individual and classical learning completeness, as well as differences in results between the experimental and control groups using t-tests and proportion tests. Qualitative analysis was conducted through data reduction, data presentation, and conclusion drawing based on the results of tests, questionnaires, interviews, and observations. To ensure data validity, technique triangulation is used, which is comparing results from various methods on the same source. Thus, the research results are expected to provide an overview of the effectiveness of TaRL-based PBL learning assisted by liveworksheets in improving students' mathematical writing skills.

RESULTS AND DISCUSSIONS

The quality of the Teaching at the Right Level (TaRL)-based Problem-Based Learning (PBL) model with Liveworksheet support on the mathematical writing skills of students at SMP Negeri 2 Sayung was assessed through three main aspects, namely planning, implementation, and evaluation of learning. In the planning stage, the analysis was conducted based on the results of validation by experts on the learning tools, which included teaching modules, Student Worksheets (LKPD) assisted by Liveworksheet, mathematical writing ability test instruments, habits of mind questionnaires, and interview guidelines. The results of the assessment in the learning planning stage can be seen in Table 1.

Table 1. Assessment Results of the Learning Planning Stage

No	Planning	Validator				Mean	Description
		I	II	III	IV		
1	Teaching Modules	87.5	92.5	87.5	90	89.375	Verry Good

2	LKPD (Liveworksheet)	86.25	85	90	91.25	88.125	Verry Good
3	Test Questions	88	88	84	88	87	Verry Good
4	Interview Guidelines	87.5	89.58	85.4	87.5	87.495	Verry Good

Based on the results of the assessment in the learning planning stage, it can be concluded that all research tools and instruments meet the criteria of validity and are suitable for use in the learning process. The validated tools include teaching modules, Liveworksheet-assisted Student Worksheets (LKPD), mathematical writing ability test questions, and interview guidelines. All of these components were categorized as valid with high average scores from the four validators.

During the implementation stage, the learning process took place, and student engagement in learning activities in the experimental group was very good. This can be seen from the results of student activity observations, as shown by the percentage of their active engagement during the learning process, as presented in Table 2.

Table 2. Percentage of Student Activity Observation Results in the Experimental Group

Meeting	Percentage	Description
1	88.75%	Very good
2	90%	Very good
3	90%	Very good
Mean	89.58%	Very good

Based on the data in Table 2, the average percentage of student activity in the experimental group that obtained learning through the Teaching at the Right Level-based Problem-Based Learning model with the help of Liveworksheet reached 89.58% and was categorized as very good. Furthermore, the learning evaluation stage included analysis of the data obtained after the study. Based on the results of data processing using the IBM SPSS Statistics 20.0 for Windows program for each class, the data obtained is as shown in Table 3 below.

Table 3. Descriptive statistics the Posttest for the Experimental Group and Control Group

Description	Final test *(Posttest)*	
	Experiment group	Control group
Mean	75.65	68.81
Standard deviation	7.37743	7.58793
Variance	52.894	57.577
Min score	58.00	56.00
Max score	90.00	86.00
N	32	32

Table 3 shows that the average score in the experimental class was 75.65 with a standard deviation of 7.37, the lowest score was 58, and the highest score was 90. Meanwhile, the average score in the control class was 68.81 with a standard deviation of 7.58, the lowest score was 56, and the highest score was 86. Based on the results of the descriptive analysis above, it can be concluded that the actual mastery level in this study is:

$$\text{Mastery Level} = \bar{x} + 0{,}25\sigma$$
$$= 66.125 + 0.25\,(8.546)$$
$$= 68.23$$

Next, the actual and classical completeness hypotheses were tested in this study. The results of the calculations using IBM SPSS Statistics 20.0 can be seen in the following table.

Table 4. Actual Mastery Final Data (Posttest)

Test	N	t_{table}	t_{count}	Decision
Posttest	32	1.695	5.694	H_0 rejected

Based on the t-distribution table, the t-table value with α=0.05 is 1.695. Calculations using IBM SPSS Statistics 20.0 yielded $t_{count} = 5.694$ and $t_{table} = 1{,}695$. This shows that $t_{count} \geq t_{1-\alpha}$ or $5.694 > 1.695$. Therefore, it can be concluded that the average score of students in the TaRL-based PBL class assisted by liveworksheets has reached 68.23 or more (has reached actual mastery). Furthermore, the classical learning mastery test was used to determine whether the percentage of classical learning mastery in the experimental group had reached the percentage set by SMP Negeri 2 Sayung for mathematics, which is 75%. Calculations using IBM SPSS Statistics 20.0 yielded the significance values in the following table.

Table 5. Classical Mastery Final Data (Posttest)

Test	n	Sig	Decision
Posttest	32	0.062	H_0 rejected

Based on Table 5, a significance value of 0.062>0.05 was obtained. It can be concluded that the percentage of the experimental group that obtained a score of 75% or more (achieved classical learning completeness) was sufficient. Next, a test of similarity of means was conducted to determine the difference in mathematical writing ability between the experimental group and the control group. The results of the mean similarity test using IBM SPSS Statistics 20.0 can be seen in the following table.

Table 6. Mean Similarity Test of Final Data on Mathematical Writing Ability

Test	n	t_{table}	t_{count}	Decision
Final test	32	1.670	3.658	H_0 rejected

Based on the t-distribution table, the t_{table} value with α=0.05 and df = 62 is 1.670. Calculations using IBM SPSS Statistics 20.0 for Windows obtained $t_{count} = 3.658$ and $t_{table} = 1.670$. This shows that $t_{count} < t_{table}$ or 3.658>1.670. Therefore, it can be concluded that the average Mathematical Writing Ability of students in the TaRL-based PBL class assisted by liveworksheets is higher than the average Mathematical Writing Ability of students in the PBL class. Next, a proportion difference test was conducted to determine the difference in proportion between the experimental group and the control group. The results of the proportion difference test using IBM SPSS Statistics 20.0 can be seen in the following table.

Table 7. Test of Difference in Proportions of Final Data on Mathematical Writing Ability

Test	N	z_{table}	z_{count}	Decision
Final data	32	1.67	11.184	H_0 rejected

Based on the results of the proportion difference test, z_{count} is obtained, which is 11.184. The z_{table} value at a significance level of 5% is 1.67. Because the z_{count} value is greater than z_{table}, namely 11.184 > 1.67. Therefore, the proportion of students who achieved mastery in the mathematical writing ability test through the TaRL-based PBL model assisted by liveworksheets was higher than the proportion of students who achieved mastery in the mathematical writing ability test through PBL.

The description of students' mathematical writing ability was obtained from test results, HoM questionnaire completion, and research subject interviews. Qualitative data analysis was conducted by presenting the results of students' test work with excerpts from student interviews, followed by triangulation techniques to determine the validity of the test results. The following results were obtained from the HoM questionnaire.

Table 8. Results of Habits of Mind Categorization

Habits of Mind Category	Number of students
Visible	9
Developing	17
Proficient	6

HoM Categories: Apparent, Developing, Proficient. The results of the habits of mind questionnaire can be categorized into three categories, namely 9 students in the apparent category, 17 students in the developing category, and 6 students in the proficient category.

The test results were analyzed based on indicators of mathematical writing ability, namely (1) the aspect of written text (writing), in which students were required to be able to write explanations of their answers to problems mathematically, logically, clearly, and in a logical and systematic manner. (2) drawing aspect, in which students are required to be able to draw pictures, diagrams, and tables completely and correctly. (3) mathematical expression aspect, in this ability, students are expected to model mathematical problems correctly or express mathematical concepts by stating everyday events in mathematical language or symbols correctly, then perform calculations or obtain complete and correct solutions. by grouping test results with similar characteristics to form certain patterns.

Students in the HoM category appear to be grouped into two patterns of mathematical writing ability. The two patterns that were formed were then named pattern one and pattern two. Pattern one is students who are able to achieve the written indicator, totaling 7 students. Pattern two is students who achieve the written and drawing indicators, totaling 2 students. Students in the HoM category are grouped into two patterns of mathematical writing ability. The two patterns that were formed were then named pattern one and pattern two. The first pattern is students who are able to achieve the written and drawing indicators, totaling 17 students. The second pattern is students who achieve all mathematical writing ability indicators, namely written, drawing, and mathematical expression, totaling 8 students. Students in the HoM proficient category are grouped into one pattern of mathematical writing ability. This pattern is students who achieve all mathematical writing ability indicators, namely written, drawing, and mathematical expression, totaling 6 students.

Mathematical writing skills are an important skill that students need to have, because this skill allows them to express mathematical ideas, concepts, and thought processes in a structured and clear manner. Mastering this skill not only helps students organize their thoughts, but also makes it easier for them to convey problem solutions logically and systematically, thereby supporting the achievement of optimal learning outcomes (Hafeez, 2021). Students who have good mathematical writing skills are generally able to illustrate problems, explain the steps to solve them, and explain the mathematical reasoning behind them accurately, which ultimately makes them more independent and reflective learners (Sari et al., 2021). Based on the importance of this skill, quality learning is required. This study developed a TaRL (Teaching at the Right Level)-based problem-based learning model assisted by Liveworksheet to improve students' mathematical writing skills.

The quality of the implementation of the TaRL-based Problem-based Learning Model assisted by Liveworksheet on mathematical writing skills was reviewed through three stages, namely planning, implementation, and evaluation. The planning stage included the preparation and validation of learning tools and instruments. The implementation stage showed that the learning process took place with good criteria based on observation results. Meanwhile, the evaluation stage showed the effectiveness of this model in improving students' mathematical writing skills.

The learning process using the TaRL-based Problem-Based Learning model assisted by Liveworksheet applies Arthur Combs' Humanistic theory, which emphasizes that learning will be meaningful if students view the learning experience as something relevant and valuable to themselves. Combs argues that students' perceptions of themselves, their environment, and social relationships in the classroom will affect their involvement in learning. In TaRL-based learning, teachers present problems that are appropriate to the students' ability level so that they feel capable of dealing with them. The learning atmosphere is designed to appreciate every idea, provide freedom of expression, and foster students' confidence to express their mathematical thoughts in writing.

Research by Simanjuntak et al. (2025) shows that humanistic theory-oriented learning approaches, such as giving students the freedom to choose problem-solving strategies and build understanding through direct experience, can significantly improve mathematical writing skills. The results of this study are relevant to the application of the TaRL-based problem-based learning model assisted by Liveworksheet, because both place students as active subjects who learn according to their respective levels of development, so that the process of mathematical writing can develop more naturally and meaningfully.

Meanwhile, Piaget's theory emphasizes that cognitive development occurs through a process of assimilation and accommodation, in which students construct new knowledge by connecting it to existing cognitive structures. In this learning process, contextual problems are

given according to the formal operational stage of students' development, encouraging them to think abstractly, organize steps to solve problems, and use appropriate symbolic representations in mathematical writing. Thus, mathematical writing is not merely copying procedures, but an active process of constructing meaning and connecting new concepts with prior knowledge.

A study conducted by (Fitriyah et al., 2024) found that problem-based learning designed according to students' cognitive development stages can improve mathematical representation skills, including the ability to write down ideas and problem-solving steps in a coherent manner. These findings support the use of the TaRL-based problem-based learning model assisted by Liveworksheet, which directly groups students based on their level of understanding and provides problems according to their readiness zone, thus aligning with Piaget's principles of cognitive development.

Vygotsky's theory is also an important foundation, particularly through the concepts of the Zone of Proximal Development (ZPD) and scaffolding. Vygotsky viewed cognitive development as being significantly influenced by social interaction. In this learning approach, students work in small groups to discuss and develop written solutions, while the teacher provides scaffolding in the form of guiding questions, writing examples, or strategic step-by-step instructions. This assistance is gradually reduced as students become more independent. Through group discussions, students not only strengthen their mathematical understanding, but also develop habits of mind such as cooperation, flexibility of thinking, and perseverance.

Research by Pimdee et al., (2024); Pratiwi et al. (2024) shows that collaboration in problem-based learning using interactive media can accelerate the development of written mathematical communication skills through peer and teacher support. These findings are in line with Vygotsky's Zone of Proximal Development (ZPD) concept, in which the TaRL-based problem-based learning model assisted by Liveworksheet facilitates adequate interaction and scaffolding so that students can develop mathematical writing skills beyond what they can achieve individually.

Findings from various literature support that the TaRL-based problem-based learning model is effective in developing mathematical writing skills. This model provides space for students to practice writing explanations of their answers to problems mathematically, logically, clearly, and systematically, drawing complete and accurate pictures, diagrams, and tables, and modeling mathematical problems correctly according to their ability level. The TaRL approach allows teachers to adjust materials and assignments based on student learning outcomes, thereby encouraging improvement in mathematical writing skills (Ananda Ismail et al., 2024; Sukmawati et al., 2025). TaRL-based PBL also encourages active student participation, accustoming them to planning, monitoring, and reflecting on the mathematical writing process (Mustafa, Ilmi, et al., 2024). Group discussion activities in each stage of PBL help students clarify their ideas before putting them into writing (Alghamdy, 2023; Sari et al., 2021).

In addition, habits of mind play an important role in the development of mathematical writing skills. Thinking habits such as flexible thinking, perseverance, and impulse control encourage students to be more thorough and critical in constructing mathematical arguments (Elvina, 2025; Jiang et al., 2021). Research Ahmad et al. (2023) dan Tashtoush et al. (2022) shows that positive habits of mind correlate with better writing skills, including in mathematical modeling.

The use of Liveworksheet interactive learning media also supports learning success. Liveworksheet enables the creation of interactive digital worksheets that facilitate mathematical writing exercises, provide immediate feedback, and increase student engagement (Dwi et al., 2024; Kholida et al., 2025). Interactive digital media can improve the quality of mathematical writing and conceptual understanding simultaneously (Etyarisky & Marsigit, 2022; Kustiyarto & Marhaeni, 2024). The literature also states that PBL combined with the TaRL approach and digital media such as

Liveworksheet is effective in improving mathematical writing skills (Sukmawati et al., 2025; Wardani & Sugandi, 2024). This study also proves that the TaRL-based problem-based learning model assisted by Liveworksheet is effective in improving students' mathematical writing skills.

CONCLUSION

Based on the results of the research and discussion, it can be concluded that learning with the TaRL-based problem-based learning model assisted by liveworksheets is of high quality, as seen from the planning stage which produced valid and usable tools and instruments, the implementation stage which received a very good rating, and the assessment stage which showed that the students' mathematical writing skills achieved actual and classical mastery and were better than the regular problem-based learning model. In addition, the description of mathematical writing skills reviewed from habits of mind shows that subjects in the proficient category were able to meet all indicators (written text, drawing, and mathematical expression), while subjects in the developing category were divided into two patterns, namely some only met two indicators (written text and drawing) and others met all indicators. while subjects also appear to be divided into two patterns, namely only meeting one indicator (written text) or meeting two indicators (written text and drawing). Thus, this learning model has been proven to be effective in improving the quality of learning while providing an overview of the differences in students' mathematical writing abilities according to the habits of mind category.

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