Student Interaction in Problem-Based Mathematics Learning: A Case Study of The Integration of TaRL and PBL in Time Material

Inar Rahmadhani Santosa[1], Yuniawatika[2], Lilik Bintartik[3]

[1,2,3]State University of Malang

[1,2,3]Department KSDP, State University of Malang, Malang City, Indonesia

*Corresponding author, email:

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Abstract

This study aims to describe student interactions during problem-based mathematics learning that integrates the Teaching at the Right Level (TaRL) approach and the Problem-Based Learning (PBL) model, focusing on time material. The research employs a descriptive qualitative approach to illustrate how the integration of both approaches creates meaningful interaction spaces for elementary school stud ents. The research subjects were 28 second-grade students at SDN 02 Kepanjenlor, Blitar City. The research implementation began with instrument validity testing, followed by the implementation of integrated TaRL and PBL learning, observation, and concluded with interviews. The results show that student interactions increased significantly during learning, both in terms of verbal communication, group collaboration, and active participation in solving contextual time-related problems. Based on observations of 28 students, the distribution of interaction levels was as follows: 7.14% of students (2 students) in the very high category, 64.29% of students (18 students) in the high category, 25% of students (7 students) in the low category, and 3.57% of students (1 student) in the very low category. Although there are still challenges in participation equity, the integration of TaRL and PBL generally effectively creates an inclusive and interactive learning atmosphere..

1. Introduction

Student interaction plays an important role in meaningful mathematics learning, especially at the primary school level where basic mathematical concepts are being formed. Mathematics is not only taught as a collection of formulas and numbers, but also as a tool for solving everyday problems (Radiusman, 2020). Therefore, meaningful and contextual mathematics learning becomes very relevant to real life. Problem-based learning is one of the most relevant approaches to apply, as it places students in authentic situations where they must identify, analyse, and solve problems that they often encounter in their daily lives (Murdilah et al., 2025; Rahmadani, 2019). Thus, students not only learn mathematics theoretically, but also develop higher-order thinking skills and the ability to apply mathematical knowledge in real-world contexts. This approach encourages students to build their understanding through interaction with peers and teachers, thereby deepening their understanding of mathematical concepts.

However, in reality, it shows that many primary school students still find it difficult to relate mathematical concepts to real life (Arafani et al., 2019; Tasni et al., 2025). Current learning practices often show limitations in student interaction during mathematics instruction. This is clearly seen in the learning of time material, where students often experience obstacles in understanding the abstract concepts contained therein. In time-related material, students' difficulties include reading analogue clocks, calculating the duration of activities, or understanding time unit conversions (Paramita & Purwati, 2024; Setiawan & Nuraeni, 2018). These findings are also supported by the results of interviews with teachers at SDN 02 Kepanjenlor, who stated that many students have not yet mastered the basic concepts of time, such as time units, how to read a clock, calculating duration, and converting time units that are often used in everyday life.

In addition, teachers also revealed that during the learning process, interaction between students tended to be low, with most students being more comfortable learning individually and rarely discussing with their peers. This lack of interaction resulted in students being less trained in

expressing their mathematical ideas and listening to different perspectives from their friends, which should be an important part of deepening their understanding of time concepts through collaboration and mathematical communication.

These difficulties are often caused by learning that emphasises memorising formulas without giving students the opportunity to explore the connections between mathematical concepts and real life (Intang Sappaile et al., 2024; Saputra et al., 2024). As a result, students tend to view mathematics as a collection of numbers and symbols that have no meaning in everyday life. In addition, another challenge in mathematics learning is an approach that is less responsive to the diversity of students' learning needs and the lack of interaction between students during the teaching and learning process. (Adzra Kamila Paustina et al., 2024; Akmalia Az-Zahra et al., 2024). Commonly used learning approaches tend to discourage active student participation and provide few opportunities for students to discuss or collaborate with their peers. In fact, interactive activities between students can make students accustomed to exchanging ideas, explaining concepts, or solving problems together (Alrosid et al., 2025; Rohi Saputri et al., 2025; Wulan & Dzulfadhilah, 2024). In fact, through active interaction, students can strengthen their understanding of a concept by communicating it to others and listening to different perspectives (Karina et al., 2024).

Some students stated that they had difficulty understanding the material taught because the learning process continued without sufficient understanding of the previous topic. In addition, teachers also stated that the lack of appeal in the learning process often caused students to lose interest in learning more deeply. This factor was reinforced by complaints from students who felt bored during the learning process, which had the potential to reduce their motivation to learn.

Each student has a unique zone of development, so general learning methods often cannot meet the individual needs of students. This is exacerbated by the lack of use of real-life contexts in learning, which makes it difficult for students to see the relevance of mathematics to their daily activities. The lack of an approach tailored to students' ability levels has an impact on the low level of interaction between students, as students with different abilities feel uncomfortable participating actively in group discussions. These difficulties are evidenced by research by Paramita & Purwati (2024), which highlights that second-grade primary school students often have difficulty reading the time and understanding how analogue and digital clocks work.

To overcome the challenge of low student interaction in learning time-related material, there is a need for innovative learning methods that can be adapted to different levels of student ability while facilitating contextual and meaningful learning. One approach that can be implemented is the integration of TaRL (Teaching at the Right Level) with the PBL (Problem-Based Learning) model. The TaRL approach helps teachers align learning materials with students' actual ability levels, enabling each student to learn according to their zone of proximal development (Ahyar et al., 2022; Ningrum et al., 2023). On the other hand, PBL provides space for students to actively engage in solving real problems relevant to everyday life. (Marra et al., 2024; Surtikawati et al., 2022; Wisnu et al., 2023). With this combination, interactions between students and between students and teachers increase through discussion, collaboration, and joint problem solving.

The integration of TaRL and PBL not only addresses the need for adaptive learning to accommodate students' diverse abilities, but also creates an interactive, participatory, and contextual learning environment (Khofifah et al., n.d.). This directly supports the creation of interactions between students and makes mathematics learning more meaningful and applicable in everyday life. By integrating the TaRL approach and the PBL model in mathematics learning, this study aims to describe how student interactions occur during problem-based learning on time-related material. The focus of this study is on patterns of communication, collaboration, and student participation in learning groups when solving everyday problems related to the concept of time.

2. Method

This study uses a qualitative approach with a case study design to explore and describe the dynamics of student interactions during problem-based mathematics learning developed through the integration of the TaRL (Teaching at the Right Level) approach and the PBL (Problem-Based Learning) model. A case study is a series of scientific research activities conducted intensively, in detail, and in depth on a particular programme, event, or activity, whether at the individual, group,

institutional, or organisational level. The aim is to gain a deeper understanding of the phenomenon being studied (Ilhami et al., 2024).

This study involved 28 second-grade students at SDN 02 Kepanjenlor, Blitar City, with 11 male students and 17 female students as the research subjects. Data collection was carried out through direct observation during the learning process, in-depth interviews with teachers and several students, and analysis of documents such as field notes, photos of classroom activities, and student work.

To ensure consistency and objectivity in the collection of observation data, the researcher used a student interaction observation rubric that had been compiled based on indicators of social and academic interaction during the learning process. This rubric covered aspects such as student participation, verbal and nonverbal communication, and patterns of cooperation in groups. Observations were conducted during three planned learning sessions, namely at the beginning, middle, and end of the learning process related to the material on time. During the observation, the researcher also took field notes to document important events and developments in student interactions in real time.

Interviews were conducted twice, namely one initial interview with the class teacher before the implementation of learning to determine the initial conditions of the students and the learning plan, and one final interview with the teacher and three students selected based on their level of participation and academic ability. The interviews used a semi-structured interview guide tailored to the research objectives.

The collected data was then analysed thematically to identify patterns of interaction, forms of communication, and dynamics of collaboration that emerged when students solved mathematical problems in the context of time. Data validity was obtained through triangulation of sources and methods to ensure the accuracy and reliability of the research findings. This process enabled the researchers to gain an in-depth understanding of how students interacted and collaborated in completing tasks related to the concept of time.

This study used learning with the integration of the TaRL approach and the PBL model. The TaRL stages in this study went through four main stages, namely assessment, grouping, learning, and evaluation (Aulia et al., 2025; Safitri & Agustina, 2024). Meanwhile, the PBL model syntax is implemented through five main syntaxes, namely: (1) Orientation, where students are introduced to contextual problems related to time; (2) Organising students for learning, namely the formation of heterogeneous groups that support active interaction; (3) Guiding individual and group investigations, where students seek information and solve problems independently or with group mates; (4) Developing and presenting results, namely the presentation of solutions by groups to the class; and (5) Analysing and evaluating the problem-solving process (Nurlaily et al., 2019; Smith et al., 2023).

In the implementation of learning, the integration between the TaRL approach and the PBL model is designed so that students are not only able to solve mathematical problems related to the concept of time, but also actively interact, discuss, and work together in groups according to their ability levels. The main focus of this study is the interaction between students during the learning process, particularly in identifying how the learning approach applied affects student participation, communication, and cooperation.

3. Results and Discussion

Interaction among students in mathematics learning is one of the important factors that supports the creation of an active and meaningful learning process. The interaction that occurs during learning provides opportunities for students to exchange ideas, discuss, and work together to solve problems that are relevant to everyday life (Nadzifa & Setyaningsih, 2023; Rubi Babullah et al., 2024). In this study, the integration of the TaRL approach with the PBL model was not only aimed at improving mathematical concept understanding, but more specifically at describing how student interactions were formed and developed during the learning of time-related material. Through grouping based on ability levels and the presentation of contextual problems, students were encouraged to communicate, collaborate, and participate actively in groups.

In its application, the integration of TaRL and PBL provides space for students to actively interact with each other in solving contextual problems related to the concept of time. Interactions between students are clearly seen when they discuss in groups, whether when formulating problems, looking for solution strategies, or concluding results. Students with high ability levels often help explain concepts to their friends, while students with low levels are more confident in asking questions because they feel supported by their peers. In addition, the use of real-life problems as a starting point for learning makes it easier for students to get involved, as they can share experiences and relate the concept of time to situations they often encounter. Thus, in addition to increasing student engagement, the interactions that occur also help strengthen their understanding of time-related material.

Learning was conducted over several sessions with a focus on time-related material. To aid in understanding these concepts, an integration of the TaRL approach and the PBL-based learning model was used. This approach was designed to increase student engagement and understanding through learning activities appropriate to their ability levels.

Based on observations conducted on 28 students during problem-based mathematics learning with the integration of TARL and PBL in time material, data was obtained on varying levels of student interaction. From the analysis of the observation data, it can be seen that most students showed good to very good levels of interaction in the learning process. In detail, the distribution of student interaction levels is shown in the table below.

Tabel 1. Level of Interaction

Score	Number of Student	Percentage
Very High	2	7.14%
High	18	64.29%
Moderate	7	25.00%
Low	1	3.57%

The observational data shows a predominance of positive responses from students towards the TARL and PBL integrative learning models. The high percentage of students with scores of 3 and 4 (71.43%) indicates that the problem-based approach combined with the TARL cycle is effective in encouraging active student interaction.

Students in the high and very high categories showed good participation in group discussions, good mathematical communication skills, and effective collaboration with peers. Meanwhile, students in the low and very low categories (28.57%) required special attention and additional intervention strategies to increase their involvement in the learning process.

3.1. TaRL Learning with the PBL Model

The first stage in implementing the integration of the TaRL approach and the PBL model is the initial assessment stage. In this stage, teachers conduct an initial assessment to measure students' level of understanding of the concept of time, including time units, calculations related to time, and their application in everyday situations. The results of this assessment are used not only to determine students' initial abilities but also as a basis for forming learning groups according to each student's ability level. In addition, this assessment serves to introduce students to the contextual problems they will encounter during the learning process (Irsyad et al., n.d.). The results of the initial assessment are then used in the PBL model, specifically in the second syntax, which is organising students into learning groups, as a basis for differentiating learning activities according to each student's ability level. Based on the pretest scores, students are grouped into three levels, namely low, medium, and high, so that teachers can design more specific learning that suits the learning needs of each group. In practice, students are asked to complete a pretest covering material appropriate to the characteristics of Year 2 students. To make them easy to understand and visually appealing, the questions were made as interesting as possible (Kartikasari & Ratu, 2020). The

questions were designed with cognitive levels in mind so that the stimuli provided in the learning process could be conveyed appropriately. The questions included essay questions and matching questions.

The second stage in implementing the TaRL approach is the formation of groups based on students' abilities after the pretest results are obtained (Dwi Ratna Sari et al., 2025). Students are grouped into three groups, namely low, medium, and high. This grouping stage is included in the stage of guiding individual and group investigations in PBL. The grouping of students aims to build knowledge through discussions among group members. During the learning process, students solve problems by working together with their groups. By adjusting the level of difficulty of the material for each group, the material will be easier for students to understand. In addition, students will find it easier, more comfortable, and less stressful to interact with friends in a group that matches their abilities. This is in line with the research by Ahyar et al. (2022), Hadiawati et al. (2024), and Meishanti & Fitri (2022), which states that the application of the TaRL approach helps students learn according to their ability level, reduces confusion, and effectively improves their mathematical abilities.

Students in the low group are given simple problems such as reading analogue clocks, the medium group calculates the duration (fast or slow) of activities, while the high group solves more complex problems, such as calculating the duration of time in minutes and hours. This is in line with Carol A. Tomlinson's learning theory, which emphasises the importance of learning based on student needs (Purba et al., 2021). Grouping students using the TaRL approach means that the material given to each group is tailored to that group's level. Meanwhile, the PBL model provides facilities for each student to connect the time material given with other concepts and real contexts so that learning becomes more relevant to problems, as described by Barrows and Tamblyn (Marra et al., 2024).

During the learning stage, students are given materials and activities tailored to the ability level of each group. The first group, consisting of students with low abilities, focuses on understanding basic concepts of time, such as recognising different types of clocks and telling the time using analogue clocks. The second group, which has intermediate abilities, learns how to calculate duration and time differences between daily activities and apply this in real-life contexts. Meanwhile, the third group, with high abilities, delves into the use of digital clocks and designs more complex and systematic daily schedules.

During the learning process, students are not only focused on understanding time concepts theoretically, but are also intensively guided to develop their work in the form of products or solutions that can be presented to their friends. At this stage, the teacher gave each group the opportunity to compile and present the results of their discussions and problem-solving during the teaching and learning activities. For example, the low-ability group was instructed to create a simple daily activity table with estimated start and end times for each activity. This table helped them understand units of time and how to sequence activities logically.

The intermediate group is given a more complex task, which is to systematically calculate the duration of daily activities, such as calculating the length of study, rest, or play time, and describing the relationship between the units of time used. Each group is given the opportunity to present their work in front of the class, while other groups provide feedback, questions, or suggestions. The interactions involved various aspects, such as verbal communication when explaining ideas, collaboration among group members in preparing presentations, and active participation during question and answer sessions.

The final stage of learning was periodic evaluation. Teachers conducted a series of reflection and assessment activities as part of the closing steps in the PBL model. This stage not only aims to measure students' competency achievement but also serves as a means of providing constructive feedback that supports deeper understanding and improves the quality of the learning process.

The low group focuses on understanding basic concepts of time, such as reading analogue clocks and units of time (seconds, minutes, hours), and is given additional explanations to help them overcome difficulties during learning. The intermediate group is assessed based on their ability to calculate duration and time differences, as well as their application in daily life, such as scheduling or calculating the duration of activities. Meanwhile, the advanced group receives more in-depth input on systematic daily scheduling and efficient time allocation analysis, including considering time priorities and flexibility.

3.2. Student Interaction During Learning

The first stage in implementing the integration of the TaRL approach and the PBL model is the initial assessment stage. In this stage, teachers conduct an initial assessment to measure students' level of understanding of the concept of time, including time units, calculations related to time, and their application in everyday situations. The results of this assessment are used not only to determine students' initial abilities but also as a basis for forming learning groups according to each student's ability level. In addition, this assessment serves to introduce students to the contextual problems they will encounter during the learning process (Irsyad et al., n.d.). The results of the initial assessment are then used in the PBL model, specifically in the second syntax, which is organising students into learning groups, as a basis for differentiating learning activities according to each student's ability level. Based on the pretest scores, students are grouped into three levels, namely low, medium, and high, so that teachers can design more specific learning that suits the learning needs of each group. In practice, students are asked to complete a pretest covering material appropriate to the characteristics of Year 2 students. To make them easy to understand and visually appealing, the questions were made as interesting as possible (Kartikasari & Ratu, 2020). The questions were designed with cognitive levels in mind so that the stimuli provided in the learning process could be conveyed appropriately. The questions included essay questions and matching questions. The second stage in implementing the TaRL approach is the formation of groups based on student ability after the pretest results are obtained (Dwi Ratna Sari et al., 2025). Students are grouped into three groups, namely low, medium, and high. This grouping stage is included in the stage of guiding individual and group investigations in PBL. The grouping of students aims to build knowledge through discussions among group members. During the learning process, students solve problems by working together with their groups. By adjusting the level of difficulty of the material for each group, the material will be easier for students to understand. In addition, students will find it easier, more comfortable, and less stressful to interact with friends in a group that matches their abilities. This is in line with the research by Ahyar et al. (2022), Hadiawati et al. (2024), and Meishanti & Fitri (2022), which states that the application of the TaRL approach helps students learn according to their ability level, reduces confusion, and effectively improves their mathematical abilities.

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3.3. Student Interaction During Learning

The first stage in implementing the TaRL approach is the assessment stage, where an initial assessment in the form of a pretest is carried out to group students according to their pretest results. At this stage, there are several forms of interaction between students, even though they are not yet in active learning groups. Some students asked each other questions, although this was within reasonable limits and under the supervision of the teacher. These interactions showed that the students were curious about the questions and were trying to help each other, although this was not yet fully structured. The teacher also gave instructions to the students to stay focused and not to cheat off each other. The interactions that occurred during the pretest provided an initial picture of the social dynamics and learning styles of the students before the main learning began. The second stage in the implementation of the TaRL approach is the grouping stage, where students are grouped based on the pretest results to ensure that learning can be tailored to each student's ability level. At this stage, although grouping is based on academic ability, teachers still pay attention to the social aspects of students so that interactions during learning run harmoniously. Interactions between students begin to form when they are placed in heterogeneous or mixed ability groups, depending on the chosen learning design. The results of observations show that student interactions are greatly influenced by the compatibility between group members. Some students appear more active and enthusiastic when grouped with friends they like or feel comfortable with. They find it easier to engage in discussions, give opinions, and even take on specific roles such as note-taker or group idea explainer. Conversely, there are also students who tend to be quiet and less participatory when they dislike or feel incompatible with their groupmates.

This shows that even though they are academically capable, psychological factors and comfort in interacting affect their level of involvement in the learning process (Putri et al., 2024). This indicates that in addition to academic ability, the psychological atmosphere of the group also greatly influences the patterns of communication, collaboration, and participation of students during problem-based learning. Therefore, the role of teachers in providing appropriate guidance is very important. Teachers can help students develop an attitude of mutual respect for differences, build trust, and enhance cooperation even in groups that are not their first choice. After dividing the groups based on ability levels, the dynamics of interaction began to appear among students during the learning process. Students were given contextual problems related to time, such as making a daily schedule or calculating the duration of daily activities. Based on observations during the learning

process, interactions between students showed positive developments at each stage of the implementation of the TaRL approach and PBL model integration. Initially, some students appeared awkward in expressing their opinions or asking questions to their groupmates, especially those from groups with moderate to low ability levels. However, as the learning process progressed, the classroom atmosphere became more conducive to interaction, and students began to actively discuss and complement each other's ideas when solving mathematical problems related to the concept of time.

Students with high abilities tended to be more active in leading discussions, explaining concepts, and helping their groupmates solve problems. Meanwhile, students with moderate to low levels began to show increased participation when they felt comfortable and guided by their friends. This interaction did not only occur in the form of verbal communication, but also through collaboration in finding solutions, taking on roles in groups, and providing feedback to one another.

During the evaluation stage, particularly when presenting group work results, there was dynamic interaction, including discussions between groups. Although there were some challenges, such as domination by certain students and uneven participation, in general the learning atmosphere continued to encourage all students to play an active role. The use of roles within the group, such as note-taker or spokesperson, helped to increase student participation. During this evaluation process, interactions between students continued, both through discussions when receiving feedback and when giving each other input on the work of their group members. Such interactions can help students reflect on their understanding and encourage collaborative learning, where students can learn from friends from different ability groups (Afriadi & Fatih Hidayah, 2024).

3.4. Challenges in Student Interaction Processes

During the implementation of problem-based learning with the integration of the TaRL approach and the PBL model, there were several challenges that affected the dynamics of interaction between students. One of the main obstacles was the differences in student character within a group, which led to domination by students in the higher groups. This made students in the middle to lower groups tend to be passive because they lacked the confidence to express their ideas or ask questions. In addition, some students seemed to have difficulty understanding the flow of group discussions because they did not have a strong grasp of basic time concepts, such as reading analogue clocks or converting time units. As a result, they find it difficult to follow the direction of their groupmates' conversation, thus maximising interaction. Another contributing factor is the students' lack of interest in the problems given, especially when the problems are not relevant to their daily experiences. This situation makes some students less active and prefer to remain silent even though they are in a group discussion setting.

Teachers also face challenges in managing interactions between groups to ensure they remain productive and inclusive. Although heterogeneous groups have been formed to encourage collaborative learning, additional strategies are needed to ensure that all students have the same opportunity to present their work, contribute, and learn from each other. To overcome these challenges, it is recommended that teachers be more selective in designing contextual problems that are relevant to students' experiences and provide clear discussion guidelines. The use of role assignment techniques within groups (such as note-taker, spokesperson, or discussion leader) can also help ensure more equitable participation.

The role of the teacher as a facilitator becomes increasingly important in maintaining a conducive and supportive group dynamic. By providing appropriate guidance when students encounter difficulties and offering positive reinforcement for student participation, teachers can create an interactive and engaging learning environment. Although there are still a number of obstacles in managing interactions during problem-based learning with the integration of TaRL and PBL, these strategies can help increase student engagement and strengthen the collaborative learning process. Thus, the integration of these two approaches has considerable potential to be developed further so as to improve students' understanding of the material and their social skills.

3.2. Conclusion

Student interaction during problem-based mathematics learning with the integration of the TaRL (Teaching at the Right Level) approach and the PBL (Problem-Based Learning) model showed positive development. In the initial stage, pretest results were used to group students according to their abilities, so that learning could be tailored and interaction between students was more harmonious.

During the learning process, communication between students became more active, especially when they solved everyday problems related to the concept of time. Students with high abilities led the discussions more, but with the guidance of the teacher, students with moderate and low abilities also began to ask questions and express their ideas. Cooperation within groups also increased, especially when working on tasks such as making daily schedules or calculating the duration of activities.

Overall, the integration of TaRL and PBL effectively created a good space for students to interact, both in terms of communication, cooperation, and active participation during learning. Although there were still obstacles in managing the groups, student interaction showed a significant improvement compared to before.

Author Contributions

To promote transparency, we encourage authors to provide an author statement file detailing their specific contributions to the paper using the relevant CRediT roles: Conceptualization; Data curation; Formal analysis; Funding acquisition; Investigation; Methodology; Project administration; Resources; Software; Supervision; Validation; Visualization; Roles/Writing - original draft; Writing - review & editing. Authorship statements should list authors' names first, followed by their respective CRediT role(s). For example: Nur Hudha: Conceptualization, Methodology, Software. John Smith: Data curation, Writing - Original draft preparation. Jane White: Visualization, Investigation. Bruce Buck: Supervision. Matt Jr.: Software, Validation. Peter Long: Writing - Reviewing and Editing.

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