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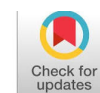
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Analysis of Students' Social Interaction During Mathematics Learning on Rational Numbers Using Vygotskian Perspectives

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ABSTRACT

Students' understanding of mathematical concepts is strongly shaped by the quality of social interaction that occurs during learning. Limited communication between teachers and students or among students can disrupt knowledge construction and weaken learning engagement. This study therefore examines (1) teacher–student social interactions in mathematics learning, (2) student–student social interactions, and (3) teachers' strategies for adjusting the difficulty level of questions to students' abilities. The study was conducted at SMP Negeri 7 Kota Jambi in May 2025 using a qualitative descriptive design. Data were collected through observation, questionnaires, interviews, and documentation, and analyzed through data reduction, data display, and conclusion drawing, with credibility ensured through source and technique triangulation. The results indicate that teacher–student interaction was in the excellent category. Teachers acted as More Knowledgeable Others by providing explanations, guiding questions, and scaffolding aligned with the Zone of Proximal Development. Student–student interaction was also excellent, as reflected in group discussions and the exchange of problem-solving strategies, although participation remained uneven. Teachers' strategies in adjusting question difficulty were likewise excellent. These results affirm that social interaction-based learning grounded in Vygotskian theory supports students' progression from actual to potential competence through collaboration and targeted instructional support.



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Introduction

Education is a learning process that enables students to understand concepts, develop maturity, and think critically. Learning is a deliberate effort to help students change their behavior in terms of knowledge, skills, attitudes, and positive values gained through experience

(Achmetli et al., 2019; Jenßen et al., 2022). Social interaction refers to the intensity of relationships that regulate how individuals behave and respond to one another. It forms the basis of structured social relationships and is a process in which individuals orient themselves toward others and act in response to what others say and do (Liu et al., 2021). Mathematics learning in schools is often perceived as challenging. Difficulties in understanding concepts and low interest in the subject frequently contribute to low student achievement (Arican, 2019; Yang et al., 2021). One way to address this issue is by creating an interactive and collaborative learning environment where students participate in discussions and cooperate with their peers. Effective social interaction in the classroom strengthens students' understanding of mathematical concepts and supports the development of social and cognitive skills.

Vygotsky's socio-cultural theory emphasizes the central role of social interaction in learning. According to Vygotsky, learning occurs within a social context where students interact with peers and more experienced individuals (Walshaw, 2017). A key concept in this theory is the Zone of Proximal Development, which describes the gap between a student's actual developmental level and the level they can achieve with guidance. Teachers provide scaffolding by giving explanations, warnings, and encouragement, then gradually reducing assistance until students can work independently (Ivars et al., 2020). In this framework, teachers serve as facilitators and mentors.

During learning, students' express opinions or ideas to obtain feedback that helps them refine their understanding. Mathematics learning requires supportive conditions that make it easier for students to engage with the material. Teaching and learning interactions should place students at the center of activities, with teachers guiding rather than dominating the process (Ayalon & Wilkie, 2020; Leiss et al., 2019; Mkhathswa, 2020). However, many classrooms still show low student participation. Some students view mathematics as difficult or intimidating, which reduces their willingness to engage actively. Not all students are ready to participate in productive social interactions. Some prefer working alone, feel uncomfortable interacting with peers, or lack confidence to ask questions. This highlights the teacher's role in creating a classroom climate that supports positive interaction. Teachers need to guide, facilitate, and encourage communication among students while providing scaffolding appropriate to individual needs.

One key topic in Grade VII mathematics is rational numbers. TIMSS results show that Indonesian students still have low mastery of fractions (Zulkardi et al., 2020). Students struggle with converting fractions to decimals, estimating multiplication of fractions, and interpreting visual fraction representations (MacDonald et al., 2025; Stevens et al., 2018). Observations and interviews with mathematics teachers at SMP Negeri 7 Kota Jambi from August 12 to September 12, 2024, revealed several patterns. Teachers provided clear and structured explanations, yet many students listened passively and rarely asked questions. Student responses tended to appear only when the teacher appointed individuals to answer. Although the teacher adjusted question difficulty to students' abilities, overall participation remained limited.

Peer interaction occurred during small group discussions. Some students helped each other explain the material and shared ideas, while others were more passive and only listened. These conditions indicate that social interaction during learning was not yet optimal. Limited interaction may lead to low participation and shallow conceptual understanding. Based on these conditions, this study focuses on analyzing the forms and quality of social interactions in mathematics learning through the lens of Vygotsky's theory. The study examines how interaction supports students' learning processes, particularly in rational numbers. Therefore, the researcher conducted a study titled "*Analysis of Student Social Interactions in the*

Mathematics Learning Process Based on Vygotsky's Theory in Rational Numbers Material in Grade VII Junior High School."

Method

Type of Research

Qualitative research produces descriptive data in the form of written or spoken words about the object being studied. Its findings do not seek to measure or calculate data numerically, but instead focus on interpretation, description, and deep understanding of the research subject (Yin, 2011). Qualitative methods position the researcher as the key instrument, employ triangulated data collection techniques, use inductive data analysis, and emphasize meaning rather than generalization. Descriptive research is conducted to determine the value of one or more independent variables without comparing them to other variables. This study uses a descriptive qualitative design, which emphasizes actual conditions in the field and aims to reveal the phenomena that occur within those conditions. The primary data sources in this study are the students of Class VII F at SMP Negeri 7 Kota Jambi and the mathematics teacher of Class VII F. Secondary data sources include learning documentation such as lesson plans, syllabi, and teacher notes used during mathematics instruction for Class VII F. Additional secondary data consist of classroom observation photos and previous research articles relevant to the topic of this study.

Participants

The research subjects are individuals who provide information related to the facts being explored. Subject selection in this study follows the characteristics of qualitative research, which emphasizes purposive sampling. Purposive sampling is a technique for selecting subjects based on specific considerations relevant to the research focus. The subjects in this study were 33 students of Class VII F at SMP Negeri 7 Kota Jambi. Class VII F was selected based on recommendations from the mathematics teachers and because the class consists of students with diverse levels of participation, ranging from highly active to passive. This variation makes the class suitable for exploring patterns of social interaction between teachers and students, as well as among students, during mathematics learning. The study also examines the teacher's strategy in accommodating students' abilities as a factor that influences these interactions, and its relevance to Vygotsky's theoretical perspective.

Instruments and Data collection

Data collection techniques are methods used by researchers to obtain information or research data and serve as a strategic component of the research methodology. To obtain comprehensive data, multiple techniques are required. In this study, observation, interviews, documentation, and questionnaires were used in parallel and complemented one another. Observation provided direct evidence of social interaction, interviews deepened the findings, and questionnaires strengthened the data through students' perceptions.

Observation was used to directly examine patterns of social interaction between teachers and students and among students, with specific attention to teachers' strategies for accommodating student abilities and the relevance to Vygotsky's theory. Observations were conducted during mathematics lessons in Class VII F at SMP Negeri 7 Kota Jambi. The observation grid based on Vygotsky's theory is presented below

Table 1. Research Instruments

No.	Research Objectives	Observed Aspects	Indicator	Instrument Form
1.	Analyzing social interactions between teachers and students in mathematics learning	The teacher asks the students questions.	The teacher asks all students in the class a general question.	Check
		The teacher asks a specific student a question directly.	The teacher calls out the students' names and asks for their answers.	Check
		Students respond to the teacher's questions	Students respond orally/in writing	Check
		Teachers provide guidance (Scaffolding)	Teachers help students understand concepts through instructions/guidance.	Check
2.	Analyzing social interactions among students in mathematics learning	Students discuss while working on problems	Students ask questions or explain to their peers	Check
		Students work together in groups	Students share tasks or help friends understand the questions	Check
		Students ask questions to their friends	Students ask their friends for explanations	Check
		Students give each other feedback	Students correct answers or give opinions on their friends' answers	Check
3.	Analyzing teachers' strategies in adjusting the level of difficulty of questions to students' abilities	Teachers group questions based on their level of difficulty	Questions are divided into easy, medium, and difficult	Check
		Teachers adjust questions to students' abilities	Teachers give different questions according to students' level of understanding	Ceklis
		Teachers give examples before giving difficult questions	Teachers guide students with simpler questions first	Ceklis
		The teacher gives students the opportunity to ask questions before working on the problems.	Teachers ensure students understand before moving on to difficult questions.	Check

Semi-structured group interviews were conducted to explore teachers' and students' perspectives on the learning process and social interactions. Interviews were held with the seventh-grade mathematics teacher and with seven groups of students, each consisting of five to seven participants. Teacher interviews were conducted individually.

Table 2. Protocols Interviews

No.	Aspect	Indicator	Points of inquiry
1.	Social interaction between teachers and students	Frequency of teachers inviting students to interact Forms of interaction Student response to teacher interaction	How often do teachers communicate with you during lessons? Does teacher interaction take the form of lectures, question and answer sessions, or discussions? Do you feel comfortable when your teacher talks to you or asks you questions? Why?
2.	Social interaction among students	The role of teachers in helping students understand Patterns of social interaction among student How students work together to complete assignments Students who are active and passive in interactions Factors that encourage or hinder interaction between students	How do teachers help you when you don't understand the material? How often do you discuss with friends during math lessons? Do you prefer to study alone or in a group? Why? Are there friends who tend to be more active in discussions than others? Why? What makes it easier or more difficult for you to communicate with your friends when learning mathematics?
3.	Teachers' strategies in adjusting the difficulty of questions	Assigning questions according to students' abilities How teachers adapt questions for students with different levels of understanding The influence of teacher strategies on student interaction The impact of giving more difficult questions	Are the questions given by the teacher at a level of difficulty that you can handle? Do teachers give different questions to students who understand faster than others? Does this teacher's strategy make you discuss things with your friends more often? If so, how? Do you feel more challenged and active in discussions if the questions given are more difficult?

The questionnaire served a similar purpose to the interview, differing only in its mode of administration. While interviews involve verbal questioning, questionnaires require respondents to complete a written instrument previously prepared by the researcher. The questionnaire produced descriptive responses rather than numerical data. Questionnaire development followed several steps: identifying the facts and opinions needed, determining the appropriate question type, drafting clear and simple questions, testing the items on a small group of respondents, revising items that caused difficulty, and distributing the finalized questionnaire.

Table 3. Questionare Instruments

No.	Research Objectives	Indicator
1.	Social interaction between teachers and students	The teacher asks the students directly. The teacher gives students the opportunity to ask questions. Teachers help students understand the material through guidance. The teacher explains again if students do not understand the concept.
2.	Social interaction among students	Students discuss with friends while doing assignments Students help friends who have difficulty understanding the questions. Students often ask their friends if they don't understand the material Students provide feedback or corrections to their friends' answers.
3.		Teachers provide examples before more difficult questions.

Teachers' strategies in adjusting question levels	Teachers provide questions with varying levels of difficulty (easy to difficult). Teachers provide different questions according to students' abilities. Teachers give students the opportunity to ask questions before working on difficult questions.
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Documentation was used to collect supporting evidence from written or recorded materials such as lesson plans, learning notes, photo archives, videos, and other relevant records. Documentation provides factual data that reinforce findings from observations and interviews. In this study, documentation included lesson-related files and visual records of classroom activities that supported the analysis of social interaction patterns.

Procedures

In this study, data credibility was ensured using a triangulation strategy. Triangulation is divided into two types: across-method triangulation and within-method triangulation. Across-method triangulation involves combining different data collection methods to verify whether the results obtained show consistent patterns. For example, observations may be complemented by interviews to address the limitations of each method. Within-method triangulation is applied during a single method, such as asking several different questions within an interview to obtain richer information. To strengthen credibility, the researcher conducted technical triangulation by cross-checking data from the same source using different techniques. Data were collected through classroom observations, interviews with teachers and students, and questionnaires administered to students. These techniques were used to compare and identify consistent patterns across data sources. Throughout the data collection process, the researcher recorded observation results in detail and supported them with documentation such as photos and videos of classroom activities. Interview data from teachers and students were fully transcribed to ensure accurate documentation and to minimize researcher bias during analysis. Questionnaire responses were then collected and analyzed to obtain additional information on students' perceptions of social interaction during mathematics learning. Finally, the researcher rechecked the observation notes, documentation, interview transcripts, and questionnaire results to ensure consistency and accuracy across all data sources. This process ensured that the findings accurately reflected students' social interactions in alignment with the indicators based on Vygotsky's theory.

Data Analysis

Data analysis is the process of organizing and interpreting data after it has been collected from all respondents or available sources. In qualitative research, data are obtained from multiple sources and through various techniques (triangulation), and are collected continuously until saturation is reached. Because the data are primarily qualitative, the analysis does not follow rigid statistical procedures but emphasizes interpretation and meaning. The results of data analysis form the basis for drawing conclusions. According to Miles and Huberman, qualitative data analysis consists of three interactive stages: data reduction, data display, and conclusion drawing. Data reduction involves selecting, simplifying, and organizing data so that it becomes meaningful and easier to interpret. In this study, data reduction was carried out to sort and organize information from observations, interviews, questionnaires, and documentation related to the social interactions of seventh-grade students in learning rational numbers, in alignment with Vygotsky's theoretical framework. Data display refers to the presentation of organized information that allows researchers to interpret patterns and

relationships. In this study, data were displayed through narrative descriptions, tables, direct quotations, and visual documentation. Observation data were presented narratively to illustrate student–teacher and student–student interactions based on Vygotsky’s concepts such as the Zone of Proximal Development and scaffolding, supplemented by photos or videos as visual evidence. Questionnaire results were presented in tabular form, while interview data were displayed using direct quotations to provide deeper insight. Conclusion drawing involves summarizing findings based on the analyzed data. In this study, conclusions were drawn by comparing data from observations, interviews, questionnaires, and documentation with predetermined indicators of student social interaction derived from Vygotsky’s theory. This process ensured that the final conclusions accurately reflected the patterns and quality of interaction observed during mathematics learning.

Results

After determining the research subjects, namely 33 seventh-grade students from SMP Negeri 7 Kota Jambi, the researchers prepared research instruments in the form of observation sheets, interview guidelines, social interaction questionnaires, and documentation. These research instruments were first validated by lecturers who are experts in the field of mathematics education. The validation results showed that all instruments were in accordance with the research indicators, with only a few editorial corrections made to make them clearer and easier to understand. Thus, the research instruments were declared valid and suitable for use in data collection.

The observation was conducted by the researcher directly during the rational number mathematics learning process in class VII F. The observation used a validated checklist containing aspects of teacher-student interaction, student-student interaction, and teacher strategies in adjusting questions. The observation was conducted several times to obtain consistent data. Interviews were conducted after the lesson on May 21, 2025. The interviews were conducted in semi-structured groups, each consisting of 5 to 6 students, so that all 33 students in the class were involved. The interview guidelines were previously validated by expert lecturers and contained questions in accordance with social interaction indicators. The interviews were conducted in the classroom during free periods so that students could answer more freely. The social interaction questionnaire was given to all students on May 23, 2025, during mathematics class, with a duration of 1 x 45 minutes. The questionnaire was in the form of a Likert scale with 5 answer choices based on 12 social interaction indicators according to Vygotsky's theory, which had been outlined in the instrument grid. Documentation was carried out during the learning process. The documentation data consisted of photos of learning activities, field notes, and lesson plans from the math teacher. The documentation served to reinforce the data from the observations, questionnaires, and interviews. In conducting the questionnaire, observation, and interviews, students showed varied responses. Most students appeared enthusiastic and serious in filling out the questionnaire and answering interview questions, although there were also some students who passive were. This condition reflects differences in individual characteristics in interacting, which were further analyzed based on Vygotsky's theory. Thus, the research instruments used, namely questionnaires, observations, interviews, and documentation, have undergone content validation and are deemed feasible, so that the data obtained can be scientifically accounted for.

In this study, the instruments used consisted of social interaction observation sheets, student questionnaires, interview guidelines, and documentation. All of these instruments were designed based on indicators of student social interaction according to Vygotsky's theory, which includes teacher-student interaction, student-student interaction, and teacher strategies in

adjusting questions. The observation instrument was compiled in the form of a checklist with 12 indicators. To ensure the validity and clarity of the instrument items, content validation was carried out by expert validators in the field of mathematics education. The validators assessed the content, language, and technical presentation. The validation results showed that the observation instrument was suitable for use with a few suggestions, namely to use it correctly and in accordance with what you have created.

The questionnaire instrument was developed using a 5-point Likert scale, ranging from “strongly agree” to “strongly disagree.” The questionnaire consisted of 12 statements in accordance with the research indicators. The questionnaire was validated by considering its content, language, neatness, and suitability for the research objectives. Based on the validation results, the questionnaire instrument was declared suitable for use. The interview instrument was compiled in the form of semi-structured guidelines with open-ended questions referring to the 12 research indicators. The interview guidelines underwent a validation process to assess the suitability of the content, language clarity, and question systematics. The validation results stated that the interview guidelines were suitable for use with the recommendation to conduct them correctly and honestly in accordance with what you have created. The documentation instrument consisted of observation sheets recording photos of learning activities and supporting documents from mathematics teachers. This instrument was also reviewed to ensure its suitability for the research objectives and was declared usable without revision. Based on the validation results, all research instruments, namely observation sheets, questionnaires, interviews, and documentation, have met the criteria for linguistic and technical feasibility so that they can be declared valid and suitable for use in collecting research data on the social interactions of seventh-grade students in Class VII F at SMP Negeri 7 Kota Jambi in learning mathematics with rational numbers. The observation was conducted on Friday, May 16, 2025, in class VII F of SMP Negeri 7 Kota Jambi. The observation aimed to determine the forms of social interaction between teachers and students, among students, and the strategies used by teachers in adjusting the material to the students' abilities. The interaction between teachers and students in mathematics learning in the classroom appears to be quite active. The results of observations show that teachers routinely open communication with students by asking questions at the beginning of the lesson. Teachers often randomly select students to answer simple questions related to previous material, then follow up on the answers with additional explanations. This activity seems to make most students more focused, although there are still some students who appear passive.

Table 4. Observations Results

No.	Observation Indicators	Results
1.	The teacher asks an open question to all students in the class.	The teacher begins the lesson with a general question to capture the students' attention, such as “Have you ever shared food with your friends?”
2.	The teacher calls on specific students to answer the question.	The teacher pointed to one of the students to answer the question.
3.	Students answer the teacher's question orally or in writing.	Students answer the teacher's questions spontaneously (orally), and occasionally they are also asked to write their answers on the whiteboard.
4.	The teacher provides hints or guidance when students have difficulty understanding the concept.	The teacher explains again and gives easier and simpler examples.

These findings are in line with the results of student interviews, which mentioned that teachers often communicate during lessons. Of the 33 students, 30 stated that teachers often

communicate, while the other 3 considered communication to be rare. One student (S2A) stated “often” when asked how often teachers interact. The questionnaire distributed also confirmed these findings, with an average score of 4.21, which is classified as very good. Documentation in the form of photos of the learning process shows the teacher standing in front of the class while asking questions to the students.

The teacher emphasized the same thing in an interview. He stated that communication with students is an important part of the teaching and learning process. The teacher said, “I always try to communicate with students so that they not only listen, but also engage in learning.” This statement shows that there is harmony between the teacher's views and the students' experiences in class.

The most common form of communication used by teachers is question and answer. Based on student interviews, 18 students mentioned question and answer as the dominant method, 12 mentioned lectures, and only 3 mentioned discussions. One student (S3A) said, “usually it's more often question and answer.” Observations also showed that teachers often asked short questions to elicit answers from students, then provided reinforcement or correction if the answers were not correct. The questionnaire results supported this data with an average score of 4.54, which is classified as very good. Documentation showed that teachers wrote questions on the board before asking students to answer. The teacher (G) himself confirmed in an interview, “I chose the question-and-answer method so that students would be more active. If I only lectured, they would quickly get bored.”

In addition to the frequency of communication, students' comfort level in interacting with teachers was also high. Most students (32 out of 33) said they felt comfortable when teachers talked to them or asked them questions, with only one student (S2C) saying they felt “somewhat comfortable.” One student (S2D) said, “It's very comfortable, it just feels closer.” Observations supported this, as several students enthusiastically raised their hands to answer questions. The questionnaire showed an average score of 4.57 in the “very good” category, reinforcing the finding that interactions with teachers took place in a conducive atmosphere. The teacher (G) also confirmed, “I always try to make students feel safe to ask and answer questions. When they feel comfortable, it is usually easier for them to learn.”

The form of assistance provided by teachers when students encounter difficulties is also evident. The results of the observation show that teachers approach students who appear confused and then re-explain the material in simpler language. A total of 27 students in the interviews stated that teachers usually re-explain the parts that are difficult to understand, while 6 students said that teachers only ensure understanding by asking questions again. One student (S5E) said, “the parts that are not understood are explained.” The questionnaire results showed an average score of 4.42, which is in the excellent category. Documentation supports this with images of teachers directly assisting students. Teachers (G) emphasized in interviews, “If there are students who do not understand, I repeat it in simpler terms. Sometimes I use examples from everyday life to make it easier to understand.”

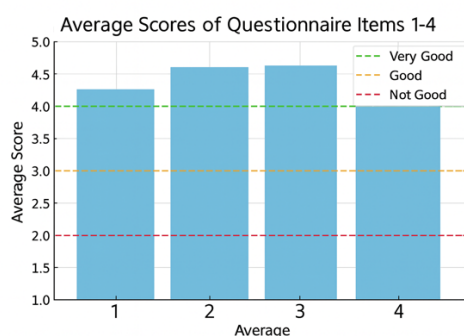


Figure 1. Survey Graphs 1-4

Based on triangulation of data from observations, interviews with students and teachers, questionnaires, and documentation, it can be concluded that teacher-student interactions in the classroom are going well. Teachers actively build communication through questions, students feel comfortable interacting, and the assistance provided by teachers is in line with student needs. This demonstrates the practice of scaffolding as explained in Vygotsky's theory, where teachers as More Knowledgeable Others (MKO) play an important role in helping students achieve new understanding.

Interaction among students in mathematics learning in class VII F Negeri 7 Kota Jambi was quite active, especially when the teacher provided opportunities for group discussions. The observation results showed that students often talked with their neighbors or in small groups when working on problems. Some students even spontaneously asked their friends if they encountered difficulties.

Table 5. Observations Results

No.	Observation Indicators	Results
1.	Students discuss with friends while working on problems.	Most students actively participated in discussions, but some worked independently.
2.	Students work together in groups to solve problems.	Group discussions were lively, even in small groups (desk mates).
3.	Students ask their friends when they do not understand the material.	Most students asked their neighbors more questions than their teachers when they did not understand something.
4.	Students provide feedback or corrections to their friends' answers.	Some students directly responded to or corrected their friends' answers.

This is reinforced by the interview results, in which 30 students stated that they often discuss with friends, while the rest said rarely or sometimes. One student (S1C) revealed, "often, when I don't understand it." The questionnaire data supports this finding with an average score of 3.93, which is in the good category. Photographic documentation also shows students pointing to answers in books. Triangulation from various data sources confirms that discussions between students have become part of the learning process, although not evenly among all students.

Students' preferences in learning also show a tendency toward social interaction. From interviews, most students (27 out of 33) stated that they preferred to study in groups because they felt they could exchange answers and help each other, while 6 students preferred to study alone for reasons of focus. One student (S1B) said, "in groups, because when we are in groups we can exchange our answers and ask whether they are correct or not". The results of the observation showed that students were more enthusiastic when asked to work in groups than when studying individually. The questionnaire showed an average score of 4.15, which is categorized as very good. Photographic documentation shows students sitting in small groups while working on problems. The teacher (G) also emphasized in an interview, "They understand more easily when they discuss. Usually, when they are alone, they give up quickly." This data indicates that group-based learning is more suitable for the characteristics of students in class VIIIF.

Student participation in discussions was uneven. Observations showed that in groups, usually only 1-2 students dominated the conversation and answered questions, while the others mostly listened. This was also mentioned by 30 students in interviews who said that some of their friends tended to be more active, usually because they were smarter or more confident. One student (S1B) said, "I think it's because he can help his friends who don't understand the material so that others can understand." The questionnaire showed an average score of 4.30,

which is in the very good category. Photographic documentation also supports this, showing several students writing their group answers on the board. The teacher (G) emphasized, "In every group, there are children who stand out. I usually encourage children to be more active in helping their friends." Data triangulation shows that this imbalance in contribution is beneficial because more proficient students act as peer tutors for their friends.

The ease and difficulty students experience in communicating with their friends is also part of social interaction. From the interview results, 23 students admitted that it was easier to communicate when they did not understand the material because they could ask questions directly using simple language, while a small number stated that communication was difficult depending on their friends' personalities. One student (S1B) revealed, "When asking whether this is correct or not, some children tend to be quiet because they usually don't understand but don't want to ask questions." Observations support this, as there are students who actively participate in discussions, but there are also students who are quiet and passive. The questionnaire gave an average score of 3.81, which is categorized as good. Photographic documentation shows discussion groups with some students appearing to be quieter. The teacher (G) confirmed, "The children want to discuss, but there are also those who are quiet. Usually, when I notice this, I ask their groupmates to engage them in conversation." Data triangulation confirms that the success of interactions between students is not only determined by the teacher's instructions but is also influenced by the students' personalities, closeness, and courage.

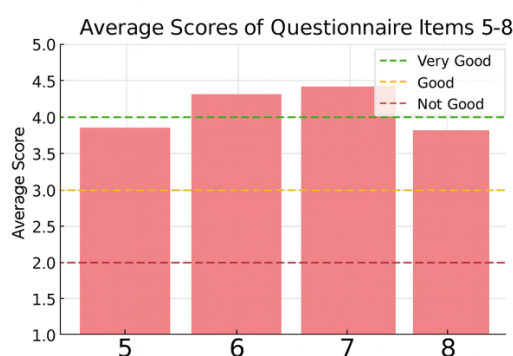


Figure 2. Survey Graphs 5-8

Overall, student interaction in learning rational numbers shows that group discussions are quite effective in helping to understand, although not all students are equally involved. Most students prefer group learning to individual learning, but student activity in discussions varies. These findings are in line with Vygotsky's theory, which emphasizes the importance of social interaction as a means of learning, whereby students are better able to help their friends in reaching their zone of proximal development (ZPD).

Teachers' strategies in adjusting the level of difficulty of questions to students' abilities are one of the important factors in supporting social interaction in the classroom. The results of observations show that the questions given by teachers can generally be answered by most students, although there are some students who experience difficulties.

Table 6. Observations Results

No.	Observation Indicators	Results
1.	Teachers differentiate questions based on difficulty level (easy, medium, difficult).	Teachers give the same questions to all students.
2.	Teachers give different questions to students with different abilities.	There is no differentiation between students who are quick to understand the material and those who are slow.
3.	Teachers give simpler examples before difficult questions.	Teachers give easy/simple questions before moving on to difficult ones.
4.	Teachers ensure students understand the instructions before working on difficult questions.	Teachers ask students if they understand before giving them the next question.

This is reinforced by the results of student interviews, in which 27 out of 33 students stated that the questions given were appropriate for their abilities, while 5 students stated that they were not appropriate, and 1 student (S1B) answered “fair” and “sometimes.” One student said, “Yes, they are appropriate, because with them we can understand the subject matter further.” The questionnaire results also supported this with an average score of 4.36, which is in the excellent category. The documentation in the form of student answer sheets shows that most of the answers were correct, although there were still some that were wrong. The teacher (G) emphasized in an interview, “I usually adjust the questions to what I have taught. So, I make sure that the questions can be answered by all students, even though their levels of understanding differ.” Data triangulation shows that, in general, the questions given were in line with the zone of proximal development (ZPD) of the majority of students.

However, teachers do not appear to differentiate questions for students with different ability levels. Observations show that teachers give the same questions to all students without differentiating the level of difficulty for students who quickly understand the material and those who are still slow. This is confirmed by student interviews, in which all respondents (33 out of 33 students) stated that teachers never give different questions. One student (S2A) briefly explained, “No, they are the same.” The questionnaire data gave an average score of 4.15 in the “very good” category, indicating that even though the questions were uniform, students still felt that they were relevant. Documentation in the form of lesson plans also showed that teachers did prepare the same questions for all students. The teachers (G) themselves admitted this in interviews: “I have never differentiated questions. I think that with the same questions, all students can try. It's just the way they work on them that is different.” Data triangulation confirms that teachers still use a uniform approach rather than a differentiated one, so that students with high and low abilities work on the same questions.

Nevertheless, the teacher's strategy was still successful in encouraging students to discuss more often. Observations showed that after the teacher distributed the questions, students tended to discuss with their neighbors or in groups to confirm their answers. Student interviews also confirmed this, with all students stating that the teacher's strategy made them discuss more often, especially when encountering difficult questions. One student (S3C) said, “Yes, by asking questions.” The questionnaire results showed an average score of 3.03, which is in the good category, meaning that not all students felt the same strong encouragement to discuss. Photographic documentation shows students discussing in small groups. The teacher added, “When I give questions, I usually ask the children to discuss them first. This allows them to exchange ideas before I discuss them with the whole class. Based on the triangulation of the above data, the teacher's strategy does encourage discussion, although the intensity and quality of the discussion still varies among students.

Furthermore, the level of difficulty of the questions was found to influence students' social interactions. Observations showed that when teachers gave more difficult questions, students

became more active in asking questions and discussing. Student interviews supported this, with 21 students feeling more challenged and active when the questions were difficult, 10 students feeling challenged and therefore more passive, while two students even felt lazy to study when the questions were considered too difficult. One student (S1B) said, “It's more challenging because we can try new things, we don't know by discussing in groups.” The questionnaire results showed an average score of 4.60, which is in the very good category, indicating that most students are indeed more stimulated when faced with difficult questions. Documentation also shows students discussing seriously when working on challenging questions. Teachers confirmed this in interviews, saying that when they give slightly difficult questions, the class usually becomes livelier. They ask each other questions and try to solve them together. Data triangulation shows that more difficult questions can increase social interaction, but the effect depends on self-confidence and peer support.

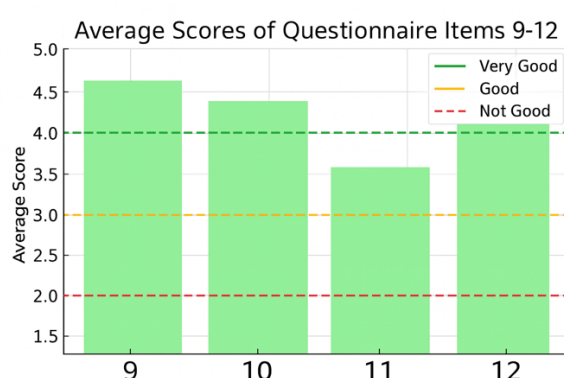


Figure 3. Survey Graphs 9-12

Overall, teachers' strategies in solving problems show two sides. On the one hand, the problems given are in line with the abilities of most students and can trigger social interaction. However, on the other hand, teachers still use uniform questions without differentiation, so that the needs of students with different ability levels are not fully accommodated. This is in line with Vygotsky's theory that effective learning occurs in the ZPD, where sufficiently challenging questions can encourage social interaction, but without adequate support or scaffolding, some students may experience difficulties.

Discussion

The results of this study show that social interaction plays a crucial role in the mathematics learning process, particularly in the topic of rational numbers. These findings reinforce Vygotsky's argument that cognitive development is inseparable from the social and cultural context in which learning occurs. Interactions between teachers and students, as well as among students, function as key mechanisms in the construction of new knowledge (Walshaw, 2017). First, teacher–student interactions highlight the role of teachers as effective More Knowledgeable Others (MKOs). Teachers communicated actively, posed questions, provided feedback, and helped when students had trouble (Freeman et al., 2020). The data show that students felt comfortable interacting with teachers, both when responding to questions and when receiving clarification. This demonstrates that teachers fulfilled their scaffolding role optimally through verbal guidance, probing questions, and explanations that supported students' progression toward deeper understanding. Thus, teachers acted not merely as transmitters of information but as facilitators who supported cognitive development within the Zone of Proximal Development (ZPD) (Norton & D'Ambrosio, 2008). Second, student–student

interactions indicate that the learning process was collaborative and reciprocal. Group discussions provided opportunities for students to share problem-solving strategies and correct conceptual misunderstandings (Sormunen et al., 2020; Stockero et al., 2020). Many students reported that they benefited from working with peers because it allowed them to exchange ideas and explore multiple solution pathways (Kuper & Carlson, 2020). This finding aligns with Vygotsky's perspective on peer-assisted learning, in which students with stronger understanding can function as MKOs for their peers. Such interactions promote collaborative learning within the ZPD and enable knowledge transfer to occur naturally.

Third, teachers' strategies in assigning questions influenced both the intensity and quality of classroom interactions. Providing tasks with varying levels of difficulty encouraged students to discuss and help one another (Álvarez et al., 2020). Tasks that aligned with students' abilities increased confidence, whereas more challenging tasks stimulated curiosity and cooperation. This reflects the ZPD principle that effective learning occurs when tasks slightly exceed students' current abilities and require external support. Although question differentiation was not implemented systematically, the variation in difficulty levels still fostered positive social dynamics in the classroom. Overall, the findings confirm the relevance of Vygotsky's theory in explaining the dynamics of social interaction in mathematics learning. Teacher–student interactions, peer collaboration, and teachers' strategies in adjusting task difficulty all contributed to the scaffolding process that supported students' movement from actual to potential levels of development (Olsher et al., 2025). Social interaction–based mathematics learning thus provides an effective approach for strengthening conceptual understanding and cultivating a collaborative classroom culture.

The findings also have several implications for mathematics teaching. First, social interaction should be positioned as a central component of learning rather than as a supplementary activity. Teachers need to design learning tasks that encourage discussion, collaboration, and active engagement. Such an approach enhances conceptual understanding and promotes mathematical communication. Second, the role of teachers as MKOs requires adaptive pedagogical skills. Teachers must understand each student's ZPD to ensure that scaffolding is timely and effective. Assistance that is provided too soon or too late may impede students' independence. Professional development should therefore include strategies for ZPD-based instructional support.

Third, the findings indicate the importance of differentiating questions to accommodate diverse learning needs. Teachers are encouraged to prepare tasks with multiple difficulty levels so that all students remain engaged. This strategy expands opportunities for peer interaction by promoting collaboration between more proficient and less proficient learners (Huang et al., 2021). Fourth, schools should support collaborative learning through policies that encourage discussion, reflection, and respectful communication. A safe and open classroom environment strengthens the quality of social interaction and nurtures students' communicative and empathetic abilities. Finally, these findings open avenues for further research. Future studies may explore the relationship between the quality of social interaction and students' mathematics learning outcomes or develop socially mediated learning models that integrate ZPD principles with differentiated instruction and interactive technologies. Applying Vygotsky's theory in mathematics education not only enriches theoretical perspectives on knowledge construction but also provides practical guidance for designing meaningful, adaptive, and collaborative learning environments.

Conclusion

This study shows that social interaction plays an important role in improving the effectiveness of mathematics learning, particularly in rational numbers. Based on data from questionnaires, observations, interviews, and documentation, social interactions between teachers and students and among students in Class VII F at SMP Negeri 7 Kota Jambi were categorized as very good. Teacher–student interactions demonstrated that teachers acted as More Knowledgeable Others (MKOs) by providing scaffolding through explanations, guiding questions, and targeted support aligned with the principles of the Zone of Proximal Development (ZPD). Student–student interactions reflected collaborative learning through questioning, discussion, and peer assistance, although participation was not yet evenly distributed. Teachers’ strategies in adjusting question difficulty also showed a positive influence on student engagement, even though individualized differentiation still requires improvement. Overall, these findings confirm the relevance of Vygotsky’s theory in mathematics learning, demonstrating that scaffolding and ZPD help students progress from their actual level of ability to their optimal developmental potential.

The implications of this study highlight the need for mathematics learning based on social interaction to be designed collaboratively and aligned with each student’s ZPD. Teachers should function not only as transmitters of information but also as facilitators who adjust scaffolding strategies to students’ learning needs. Students, in turn, should be encouraged to actively ask questions, participate in discussions, and provide feedback to peers as part of their cognitive development. This collaborative approach supports deeper conceptual understanding and fosters social skills essential for ongoing learning. The findings also reinforce the applicability of Vygotsky’s theory in junior high school mathematics education, particularly regarding the implementation of ZPD and scaffolding principles in student-centered learning.

Based on these findings, it is recommended that teachers promote more active student participation through learning activities that require cooperation and meaningful interaction. Students are encouraged to express their ideas, ask questions, and support peers throughout the learning process. Future researchers are advised to broaden the scope of investigation by considering additional factors such as instructional strategies, teacher characteristics, and the use of digital learning media to provide a more comprehensive analysis of social interaction dynamics in mathematics learning.

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Conflict of Interest

The authors declare that there is no conflict of interest.

Authors’ Contributions

The first author, D.A., played a role in designing the research, creating the research instruments, understanding the research ideas, collecting data, analyzing data, processing data, and

presenting the results and discussion of the research. The second author, R.T., participated in reviewing the research and adjusting the overall information in the research. The third author, D.I., participated in adjusting the research and discussion as well as finalizing the results of the work. The total contribution to the conceptualization, writing, and correction of this article is as follows: D.A.: 50%, R.T.: 25%, and D.I.: 25%.

Data Availability Statement

The authors state that the data supporting the findings of this study will be made available by the corresponding author, [D.A.], upon reasonable request.

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