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Evaluating Teacher-Student Interaction and the Implementation of Sociomathematical Norms in Indonesian Mathematics Classrooms

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ABSTRACT

Background: Teacher-student interaction plays a pivotal role in shaping the quality of mathematics learning. However, in many Indonesian classrooms, traditional models of instruction often dominate, limiting opportunities for students to engage in meaningful mathematical discourse.

Aims: This study aims to: (1) evaluate the patterns of teacher-student interaction during mathematics instruction in Indonesian secondary schools, and (2) examine the implementation of sociomathematical norms in a redesigned learning model using a problem-posing approach.

Methods: A qualitative research approach was adopted involving observations of eight mathematics classrooms in Lampung, Indonesia. During the odd semester, four classes were observed using conventional teaching methods. In the even semester, four teachers implemented a problem-posing model co-designed with the researcher. Data were collected via classroom video recordings and analyzed using the Flanders Interaction Analysis System (FIAS) with support from NVIVO software.

Results: The findings reveal that traditional classrooms were heavily teacher-dominated, with 86% of classroom talk attributed to teachers and only 14% to students. Common classroom norms included praying, singing, asking questions, listening to explanations, and discussions. In contrast, problem-posing classrooms demonstrated the emergence of sociomathematical norms such as mathematical explanation, differentiation of ideas, and student-generated problems.

Conclusion: The study highlights the limited interaction in traditional classrooms and the potential of sociomathematical norms to enrich student participation and mathematical discourse when implemented through structured problem-posing models. These findings inform future instructional design that prioritizes interactive and student-centered learning environments in mathematics education.

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INTRODUCTION

Social constructivist theory views learning as an active process where students engage in communication within a meaningful social context (Brennner, 1994). In mathematics classrooms, effective learning requires interactive dialogue, where students collaboratively explore ideas through teacher-guided discussions. Teachers serve a central role in ensuring that classroom dialogue flows productively and that students are actively involved in mathematical reasoning. Prior research in mathematics education emphasizes the importance of student engagement, particularly at the junior secondary level (Oppong-Gyebi et al., 2022). Contextual learning approaches aim to connect mathematical concepts with real-life experiences (Afni & Hartono, 2020; Krishnamoorthy et al., 2021), while problem-based learning provides opportunities for students to work in groups and develop their reasoning, communication, and collaborative skills (Allen et al., 2011; Meiriyanti et al., 2018).

Despite these pedagogical advances, classroom practice in many contexts, including Indonesia, remains dominated by traditional, teacher-centered instruction. Teachers often lack sufficient time or support to facilitate active discussions, leading to passive student involvement. Research has shown that such environments tend to limit students' understanding of mathematics to symbolic manipulation, rather than fostering deep conceptual knowledge (Ewing, 2011). As a result, students may develop negative perceptions of mathematics and avoid it altogether. The 2022 Indonesian national education report further highlights that classroom learning is still primarily task-oriented, and less than 50% of lower secondary students meet the minimum numeracy standards. These concerns underscore the urgency of describing and evaluating classroom processes through interaction analysis, which can reveal how teacher and student behaviors shape learning (Odiri Amatari, 2015). Through such analysis, educators can identify patterns of interaction that either support or hinder meaningful engagement and use these insights to inform more effective teaching practices.

Various studies have explored teacher-student interactions in mathematics education. For example, Niyazi & Wu (2024), Simile (2024), Zhang & Wang (2024) investigated verbal and discursive communication patterns in the classroom. Meanwhile, Druken & Marzocchi (2024), Li et al. (2024), and Plowman et al. (2024) focused on how teachers' beliefs, collaborative strategies, and empathetic practices contribute to effective instruction. Other studies, such as those by Hallarte et al., (2024), Henry J. et al. (2024), and Wijaya et al. (2024) emphasized the role of technology, digital learning materials, and emotional support in shaping classroom interaction, especially in STEM contexts. Additionally, Post and Prediger (2024), Amador et al. (2024), and Bezmalinovic (2024) addressed how mathematical representations are connected and how instructional settings are designed. Wang et al. (2024) and Sasidharan and Kareem (2024) highlighted the importance of teacher-student relationships in reducing math anxiety and promoting a sense of school belonging.

However, these studies have rarely addressed how sociomathematical norms—shared understandings of what counts as acceptable mathematical reasoning—are developed and enacted during classroom interactions. Even fewer have examined how such norms emerge within problem-posing instruction, particularly in developing countries like Indonesia, where traditional, teacher-centered methods still dominate. Therefore, this study aims to fill that gap by evaluating teacher-student interaction and identifying emerging sociomathematical norms within mathematics instruction at the junior secondary level, using Flanders Interaction Analysis combined with qualitative analysis supported by NVIVO software.

METHOD

Research Design

This study employed a qualitative research design aimed at exploring the interaction patterns between teachers and students during mathematics instruction. The research was conducted over two semesters within the 2022/2023 academic year. In the first phase, the researcher observed classroom practices during regular mathematics lessons. In the second phase, the researcher collaborated with teachers to implement a redesigned instructional approach using the problem-posing model.

Participants

The participants in this study were junior secondary school students and their mathematics teachers from eight classrooms in Lampung, Indonesia. During the odd semester, the researcher observed mathematics lessons in four schools, focusing on the dynamics of classroom interaction. These lessons were documented through video recordings. In the even semester, the researcher partnered with four other schools to implement the problem-posing model. The collaboration involved regular meetings between the researcher and participating teachers to co-develop instructional plans and discuss strategies for promoting sociomathematical norms. Initially, lessons were co-taught, but over time, teachers gradually took the lead as they gained confidence in applying the new model. Weekly reflection meetings were conducted to evaluate progress and adjust instructional strategies.

Instruments

Data were collected using field notes, classroom video recordings, and observation sheets. These instruments captured both verbal and non-verbal aspects of classroom interactions. The focus was on how teacher and student behaviors evolved during the implementation of the redesigned instructional model.

Data Analysis

The collected data were analyzed using qualitative content analysis. All video recordings were transcribed and coded using NVIVO 12 software. Coding was organized into two primary dimensions: teacher behaviors and student behaviors. Within these two categories, the researcher developed 17 distinct codes representing recurring classroom activities. To further structure the analysis, the study applied the Flanders Interaction Analysis System (FIAS), which classifies verbal communication into ten categories: seven for teacher behaviors (accepts feeling, praises or encourages, accepts ideas, asks questions, lectures, gives directions, criticizes or justifies), two for student responses (responds to teacher, initiates), and one for silence or confusion. However, this study focused exclusively on teacher and student interactions. The analysis aimed to identify patterns of discourse and how they reflected the emergence of sociomathematical norms during both traditional and problem-posing instructional settings.

RESULTS AND DISCUSSION

Results

Traditional Classrooms

The researcher analyzed classroom data using three main indicators: the number of coded references, the total word count, and the percentage distribution of words. During the analysis process using NVIVO 12, the researcher systematically coded each segment of the recorded classroom narratives. Any word or sentence indicating specific instructional activities was highlighted and categorized as a reference. The distribution of classroom activities conducted by both teachers and students is illustrated in Figure 1.

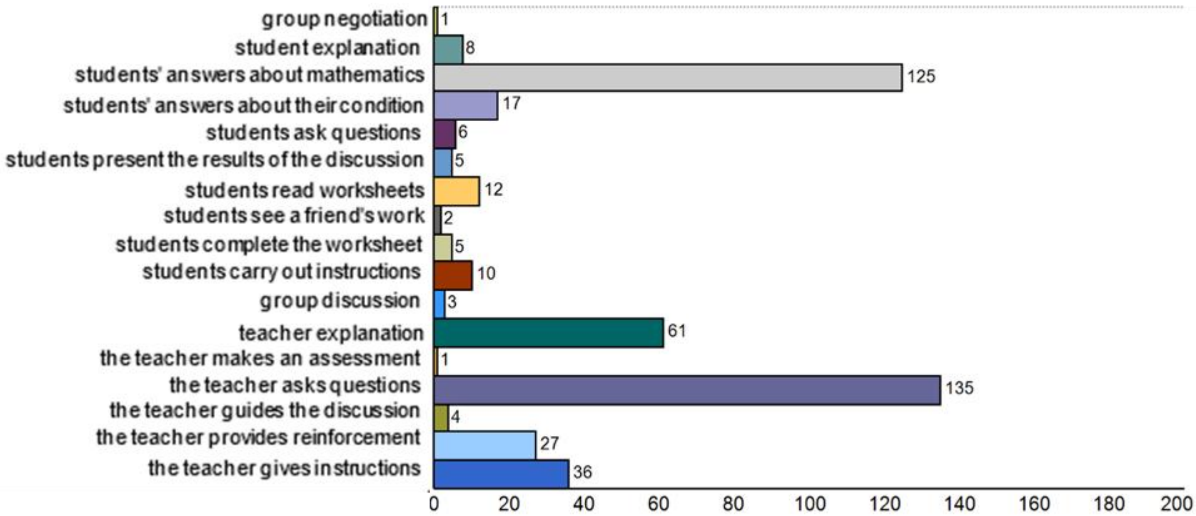

Figure 1. Based on reference

A total of 17 distinct classroom activities were identified and coded (see Figure 1). The teacher's most frequent actions included asking questions and delivering explanations, while the students most commonly responded with answers—either related to mathematical content or situational aspects. These findings indicate that classroom interaction was predominantly teacher-driven, particularly in terms of questioning and instruction.

For the second criterion, data were analyzed based on the total number of words spoken by both teachers and students (see Figure 2). The word count provides insight into the communication patterns and level of verbal engagement that occurred during the lesson.

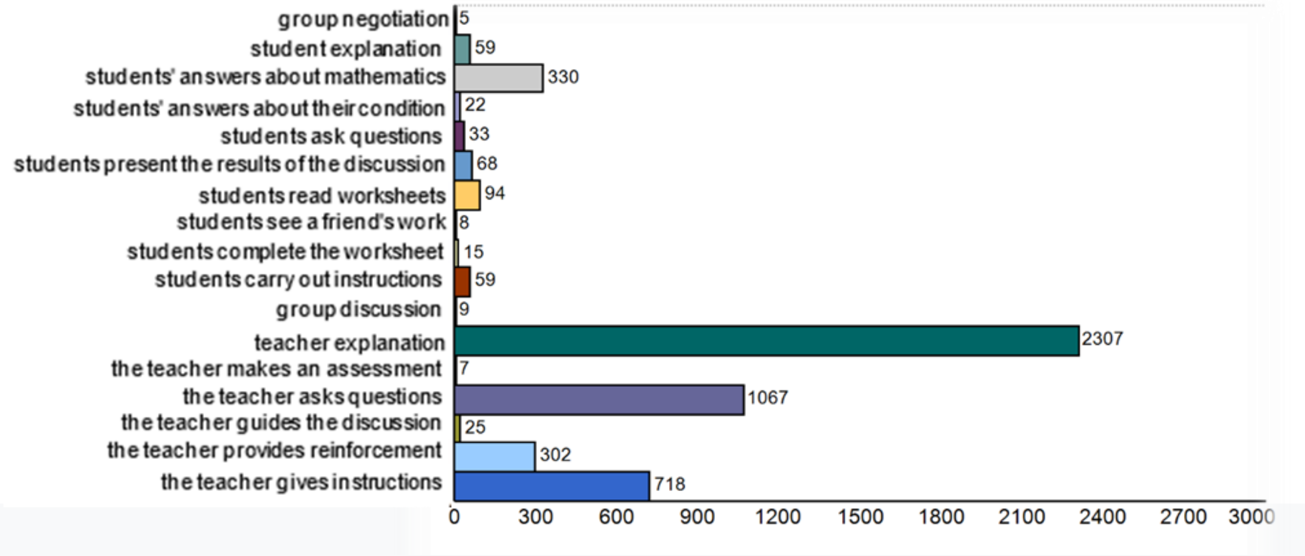

Figure 2. based on the number of coded words

Based on the recorded word count, the teacher's explanations accounted for the largest proportion, followed by asking questions and giving instructions—all of which are teacher-led activities. Among student activities, the most frequent was providing responses related to mathematical content.

The proportion of teacher and student discourse throughout the lesson is summarized in the following table. These figures were calculated from the total volume of verbal exchanges observed during the instructional process.

Table 1. Distribution of Teacher and Student Activities During Mathematics Lessons

Aspect	Activities	Percentage	Total percentage
Teacher	gives instructions	14%	86%
	provides reinforcement	5.89%	
	guides the discussion	0.49%	
	asks questions	20.81%	
	makes an assessment	0.14%	
	gives explanation	44.99%	
Student	group discussion	0.18%	14%
	carry out instructions	1.15%	
	complete the worksheet	0.29%	
	see a friend's work	0.16%	
	read worksheets	1.83%	
	present the results of the discussion	1.33%	
	ask questions	0.64%	
	answers about their condition	0.43%	
	answers about mathematics	6.44%	
	give explanation	1.15%	
	group negotiation	0.1%	

As shown in Table 1, teacher talk accounted for 86% of the total classroom discourse, while student contributions made up the remaining 14%. However, when examining the range of activities identified during the lessons, a greater variety of student-initiated actions were observed.

Teacher Activities

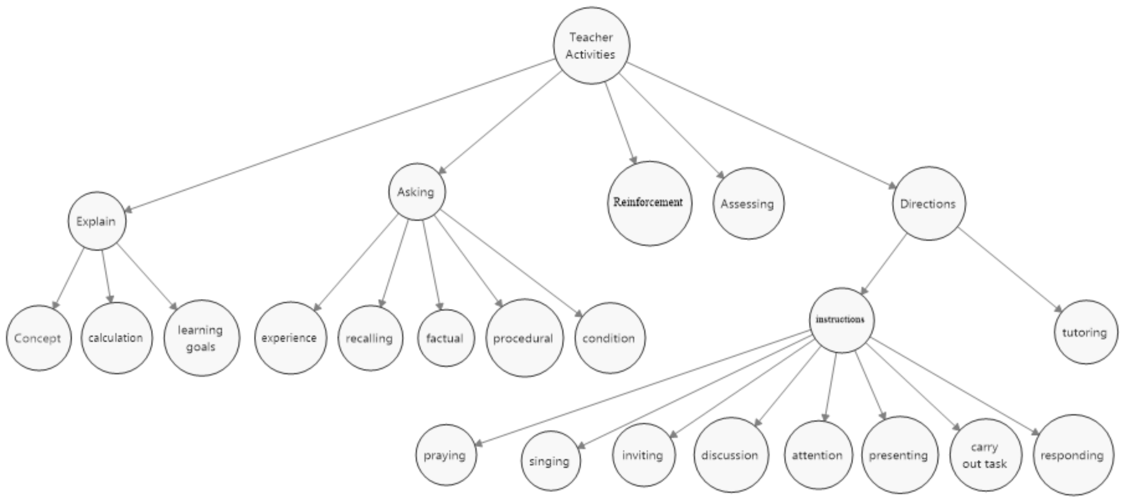

Figure 3. Teacher Activities in Mathematics Instruction

The six coded teacher activities identified in the first stage of analysis were further classified using the Flanders Interaction Analysis framework. Four of these activities—giving directions, providing feedback or justification, asking questions, and delivering explanations—aligned with the original categories proposed by Flanders. Additionally, a new category emerged from the current study that is not included in the Flanders framework: assessing students' discussion processes. This unique activity highlights the evolving role of teachers in managing classroom discourse (see Figure 3).

Provide direction

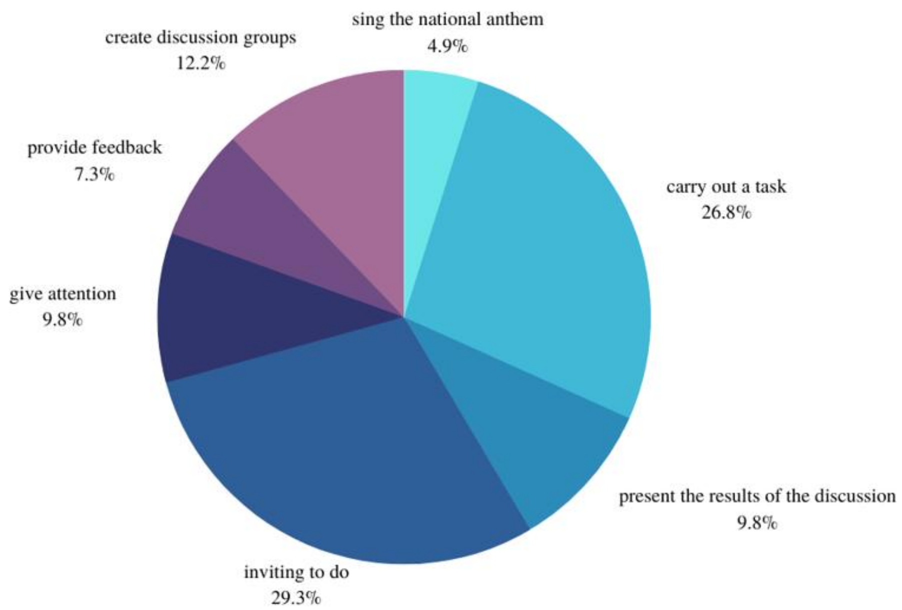

Figure 4. Percentage of Teacher Directives in the Classroom

The "giving directions" category was further divided into two subcategories: instructional directives and group guidance. Instructional directives typically appeared at the beginning of lessons and included prompts such as asking students to pray, singing the national anthem, and forming groups. These routines reflect educational norms aligned with Indonesian national policy, which emphasizes religious values and patriotism as part of its educational goals. Another prominent social norm observed was that students tended to engage in activities only after receiving explicit permission from the teacher, as illustrated in the following transcript excerpt.

Teacher: Do you still remember how to calculate the price of 1 kg of oranges and 1 kg of apples?
Student: Yes, ma'am.
Teacher: Alright, go ahead, Rizki.
Student: By using substitution...
Teacher: That's absolutely right, Rizki. You remembered it well.

In the dialogue, it is evident that the student responded to the teacher's question only after being given permission to speak. The student raised his hand beforehand and waited for the teacher's acknowledgment before delivering his answer.

Ask questions

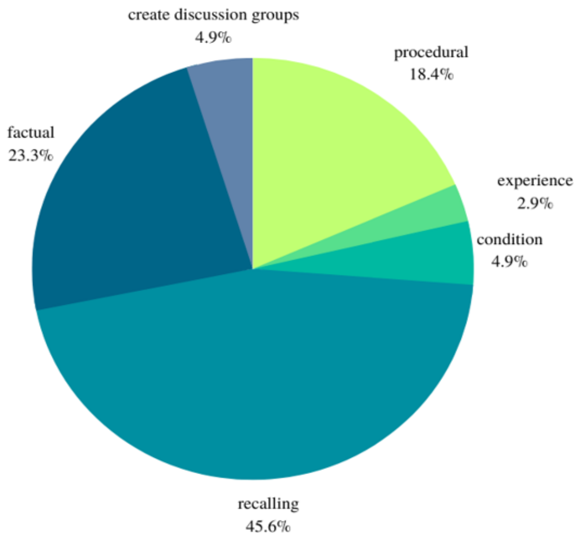

Figure 5. Types of Teacher Questions in the Classroom

Among all teacher activities observed, asking questions was the most frequently coded, with 135 references identified across the data set (see Figure 5). However, word count analysis revealed that the amount of spoken words associated with teacher questions was lower than that of explanations (see Graph 2). Most of the questions posed by teachers were related to recall, factual information, and procedural steps.

Recall and factual questions typically required single, short answers, offering little opportunity for follow-up discussion or the emergence of alternative student ideas. Procedural questions in this study were generally embedded within whole-class explanations, where the teacher posed questions while simultaneously demonstrating problem-solving procedures at the front of the classroom. The following is an example of a procedural question related to arithmetic operations presented during direct instruction.

Teacher: So, if it's fifty thousand per unit, what's the total purchase price?
Student: Five hundred.
Teacher: Five hundred thousand, then multiply by?
Student: One hundred.
Teacher: One hundred percent—smart! From here, is there anything that can be canceled out?
Student: Yes.
Teacher: From here, you can cancel it. Now with the hundred, it's gone. And then those two zeros—can they be simplified here?
Student: Yes.

Explaining

Delivering explanations (lecturing) was one of the most frequently observed teacher activities in mathematics classrooms (see Figure 6). These explanations generally focused on mathematical content and procedural steps. Teachers also introduced learning objectives, including core competencies and specific indicators, which are essential for helping students understand what they are expected to achieve. However, the way these explanations were delivered—often by reading directly from prepared teaching materials—tended to consume a significant portion of instructional time.

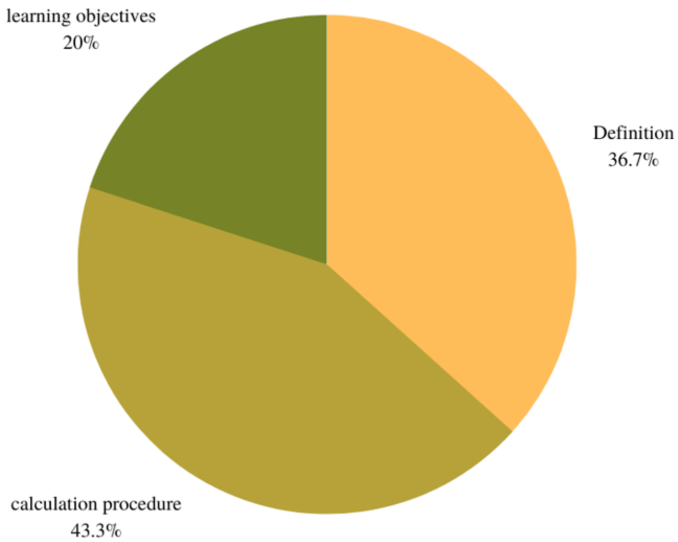

Figure 6. Percentage of Teacher Explanation

Student Activities

According to the Flanders Interaction Analysis framework, student behaviors are categorized based on their initiation—either as responses to teacher prompts or as self-initiated contributions. These behaviors reflect students' intellectual autonomy, which is often influenced by the presence of sociomathematical norms in the classroom. In this study, eleven distinct student activities were coded and subsequently reclassified in a second-stage analysis using Flanders' student dimension categories. The distribution of these activities is illustrated in Figure 7.

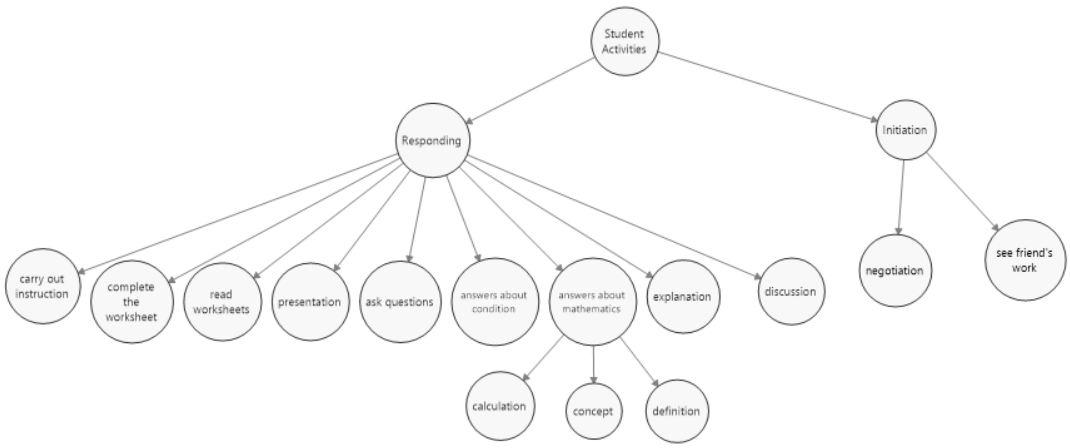

Figure 7. Student Activities in Mathematics Instruction

Two student activities were identified as self-initiated, while the remaining actions were responses to teacher instructions. Self-initiated behaviors typically occurred during group discussions, where students explored alternative solution strategies. Some students were observed observing how their peers completed tasks without actively contributing to the discussion; instead, they simply copied their peers' work within the group.

As shown in Figure 8, the most frequent student behavior was responding to teacher questions. However, the quality of student responses tended to be procedural, focusing primarily on continuing calculations rather than offering conceptual insights. Students were not given the opportunity to engage in multidirectional discussions that might have allowed them to critique or build upon others' ideas. Instead, teachers typically confirmed the responses and proceeded with direct explanation.

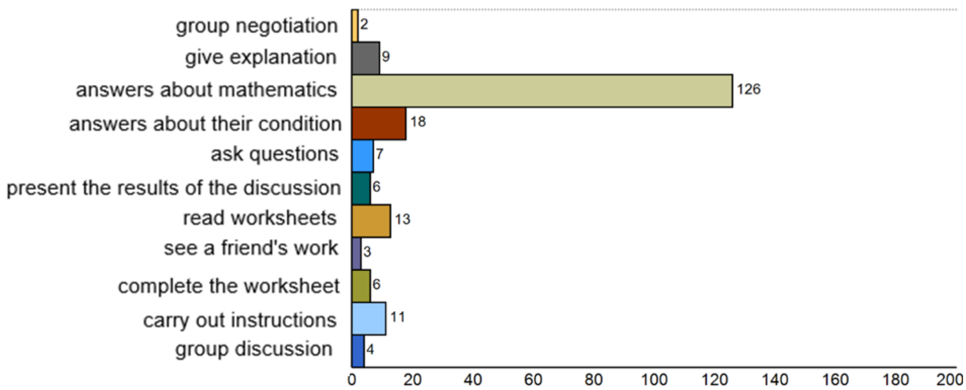

Figure 8. Student Activities in Mathematics Lessons

As illustrated in Figure 8, the observed classroom interactions primarily reflected social norms—such as students responding to teacher questions, working in groups, and completing assigned tasks. In contrast, sociomathematical norms, which emphasize mathematical argumentation and justification during discussions, were less evident. Of these, negotiation among students was the only sociomathematical behavior observed, and it occurred infrequently.

Problem-Posing Classrooms

Classroom Social Norms

Mathematics instruction was carried out following a structured set of learning phases developed as part of the instructional model. Each phase was associated with specific social norms that guided classroom behavior. In earlier observations, teacher questioning was largely limited to closed-ended prompts, and although students were placed in group discussions, sociomathematical norms—such as providing mathematical explanations, expressing differing mathematical ideas, or constructing arguments—were not yet evident. The problem-posing learning model was designed to involve both teachers and students in collaborative group work and teacher-led classroom dialogues. The following section outlines each instructional phase, and the corresponding norms established during implementation.

1. **Apperception Phase**

   In this initial phase, students engaged in large-group discussions where they were encouraged to share personal experiences and explain their ideas. Many students enthusiastically expressed their thoughts, sometimes simultaneously. To maintain order, the teacher then established a social norm requiring students to raise their hands before speaking and to listen attentively before responding.

2. **Understanding the Situation Phase**

   Students were placed in small groups and involved in observation and collaborative work. The primary social norm emphasized mutual cooperation (*gotong royong*), where students were expected to contribute, share ideas, and offer feedback during group tasks. The teacher actively facilitated inclusive participation. Students also held one another accountable, prompting peers who were not actively involved. Task-sharing became common practice. At the end of this phase, the teacher led a class-wide discussion to encourage students to confidently articulate their thoughts.

3. **Problem-Posing Phase**

   In this phase, students began to formulate their own problems. Initially, they were guided to modify existing problems but later gained autonomy to generate questions independently. Group visits were conducted, allowing students to share and compare the problems they had created. The teacher often invited peers to respond or offer feedback on each other's problems and encouraged them to generate and refine new mathematical questions.
4. **Problem-Solving Phase**

   Students were given the opportunity to solve the problems they had created. This phase was structured around class discussions facilitated by the teacher. The guiding classroom norm was *deliberation*, where students were expected to listen carefully to others' explanations. If disagreements arose, they were encouraged to explain their reasoning and respectfully justify why they did not accept a particular idea.
5. **Reflection Phase**

   After completing the group discussions and problem-solving tasks, students returned to their seats. The teacher instructed them to do so quietly and with self-control. During the reflection session, selected students were invited to share their experiences and insights from the lesson. Students expressed their thoughts only after being called on or given permission by the teacher, reinforcing norms of orderly participation and self-regulation.

Sociomathematical Norms

Sociomathematical norms were established from the outset of the instructional process. These norms were aligned with the culturally responsive problem-posing learning model implemented in the study. Unlike the framework proposed by Yackel and Cobb—which identifies explanation, difference, and elegant solutions as the core elements of sociomathematical norms—this study identified *problem posing* itself as an additional key component. Throughout the lessons, the research team and participating teachers conducted weekly planning sessions to determine follow-up tasks and concluded each lesson with a reflection process by compiling a "look book" of classroom activities. The following section describes the sociomathematical norms that emerged during the implementation of the problem-posing approach.

Mathematical Explanation

Students were expected to provide mathematical explanations or justifications until their answers were deemed acceptable by classroom standards. For example, the teacher prompted students to focus on a triangle with side lengths 4, 4, and 4, and asked them to determine its type (January 17, 2023).

Student: It's an acute triangle.
Teacher: Why do you say it's acute?
Student: Because the shape looks sharp.
Teacher: Hmm...
Student: Because the angles are less than 90 degrees.
Teacher: Can you show that?
Student: Using a protractor... the angle measures 60 degrees, ma'am.
Teacher: Is there another way?
Student: (silent)
Teacher: What is the relationship between the three sides of an acute triangle?
Student: $c^2 < a^2+b^2$
Student: All sides are equal.
Teacher: So if a,b,a, b,a,b, and ccc are all 4, is it an acute triangle?
Student: Yes, ma'am. Because 16 is less than 32.

Mathematical Differences

Within the context of this study, the problem-posing model defined mathematical difference in terms of generating alternative solutions and proposing varied problems. Additionally, observed sociomathematical norms included student justifications regarding the similarity of ideas (January 16, 2023). During a lesson on Pythagorean triples, the teacher guided students to work in groups and formulate new problems related to the topic. Students generated variations by altering the given numerical values in their problem statements. The following excerpt

Teacher: Group 1, what are the other side lengths of your triangle?
Student: Ten, seven, and seven.
Teacher: Group 3, can you determine if it's a Pythagorean triple?
Student: It is a triple, Ma'am.
Student: No, it's not... fourteen plus fourteen and ten are different.
Teacher: Fourteen?
Student: Seven squared, seven times two.
Student: Seven squared is forty-nine.
Student: Wait… let's recalculate.
Student: Ninety-eight and one hundred, Ma'am—they're different.
Teacher: So what's the conclusion?
Student: It's not a Pythagorean triple.

The dialogue reveals that students proposed differing answers regarding whether the side lengths 10, 7, and 7 constitute a Pythagorean triple. While one student claimed it was a triple, others disagreed. The teacher prompted students to justify their reasoning. When a student initially calculated $7^2=14$, a peer quickly corrected the mistake, clarifying that $7^2 = 49$. Mathematical difference was also observed in the presentation of varied results using the same procedure. This is further illustrated in the following excerpt.

The teacher used GeoGebra to draw a right-angled triangle with both legs measuring 4 cm, then asked students to calculate the length of the hypotenuse.

Teacher: Zen, what is the length of the hypotenuse?
Student: 5... maybe five point something, Ma'am.
Teacher: How did you get that?
Student: $16 + 16 = 32$, so it's roughly around 5,0.
Teacher: Why 5?
Student: Because $5 \times 5 = 25$, which is too small, and $6 \times 6 = 36$, which is too much. Since 32 is between 25 and 36, the answer should be about 5.
Teacher: Does anyone have another solution?
Student: $\sqrt{32}$
Teacher: Can you explain?
Student: $16 + 16 = 32$, so $c = \sqrt{32}$
Teacher: Any other solutions?
Student: $16 + 16 = 32$, $\sqrt{32} = \sqrt{8 \cdot 4} = 2\sqrt{8}$

The teacher then asked the class to evaluate all three responses, but no students offered a justification regarding which one was most appropriate. The teacher used MS Excel to show the calculation of $\sqrt{32}$, $2\sqrt{8}$, guiding students toward drawing a conclusion.

Teacher: What can you say about the answers: 5, $\sqrt{32}$ dan $2\sqrt{8}$.
Student: $\sqrt{32}$ dan $2\sqrt{8}$ are equivalent, and both are close to Zen's answer of 5—but Zen didn't specify the exact decimal.

Mathematical Problem Posing

Students were instructed to formulate a single mathematical question. Based on their written responses, the researcher classified the questions into three categories. The first category consisted of questions that were structurally similar asking whether a given set of three numbers formed a Pythagorean triple but with variations in the numerical values used. A total of 22 students submitted problems of this type. Among them, four students verified their sets beforehand by calculating and confirming that the numbers indeed satisfied the Pythagorean condition. One student posed a problem involving significantly larger numbers than those used by peers, asking whether 101, 99, and 150 formed a Pythagorean triple.

The second category included students who changed the numbers and posed a different type of question, such as "What is the name of this triangle?" or "Is this triangle obtuse?" These students engaged in small-group discussions to select two problems for collective exploration. In another session focused on real-life applications of the Pythagorean Theorem, students generated a broader range of problem types, indicating increased creativity and contextual thinking.
The teacher walked around to observe students' work.

Teacher: What kind of problem are you planning to create?
Student: Can we change the numbers, Ma'am?
Teacher: So, the context remains the same—someone climbing a tree?
Student: Yes, Ma'am.
Teacher: Okay, that's fine. Go ahead.
Student: We want to change the story, Ma'am.
Teacher: And the numbers?
Student: We're not changing the numbers.
Teacher: Alright.
Student: We're changing both the story and the numbers, Ma'am.
Teacher: Okay.

During this activity, some students were observed submitting incomplete problem statements.

Teacher: Where is the problem you've created?
Student: Here it is, Ma'am.
Teacher: How is it different from the previous one?
Student: The story has been changed, and the numbers too.
Teacher: (Reading the problem) Hmm... something seems to be missing. How far is the ladder placed from the wall?
Student: *[Thinking, silent]*
Teacher: What if the ladder is placed directly against the wall?
Student: Then it wouldn't work, Ma'am.
Teacher: So how far should it be placed to make it usable?
Student: *[Discussing with peers]* ...Five meters.

In general, students created new problems by modifying the numerical values. However, several students also developed entirely new contexts—for example, replacing a story about ladder placement with one involving a kite. Some students constructed incomplete problems, prompting the teacher to engage them in dialogue to revise and clarify their questions. This process helped encourage more open-ended problem posing.

Discussion

Indonesia's national mathematics curriculum emphasizes the importance of student-centered learning. At the secondary school level, instructional practices are expected to align with the principles of social constructivism, encouraging students to actively construct knowledge through collaborative problem-solving activities (Oppong-Gyebi et al., 2022; Allen et al., 2011; Meiriyanti et al., 2018). However, findings from this study reveal that during mathematics instruction, 86% of classroom discourse was teacher-dominated, with only 14% originating from students. This indicates that, despite curricular expectations, instructional practice in Indonesian junior secondary schools remains largely teacher-centered.

These findings align with Flanders' earlier work, which reported that classroom talk typically consists of 80% teacher talk and 20% student talk at both elementary and secondary levels (Odiri Amatari, 2015). Although the proportions are similar, the slightly higher percentage of teacher discourse in the present study suggests that passive transmission models still dominate in practice. While teachers did place students in group discussion settings and provided activity sheets, these tools were often used to complete exercises rather than to foster meaningful mathematical dialogue or collaborative knowledge building. This outcome is consistent with national education reports, which indicate that classroom instruction in Indonesia continues to emphasize task completion over conceptual exploration.

Mathematics instruction in Indonesia is embedded with unique classroom norms. Lessons often begin and end with a prayer, reflecting the country's deeply rooted religious values. As a nation that acknowledges belief in God, Indonesia's national education goals emphasize the development of religious competence. Prayer is understood as a means of seeking divine support for a smooth learning experience. This study also found that it is common for teachers to begin mathematics lessons by singing national songs. This practice serves as a way to cultivate patriotism and national identity among students, aligning with the curriculum's emphasis on instilling the values of *Pancasila* in the younger generation.

Teachers must recognize that high-quality communication in mathematics classrooms involves fostering meaningful connections between teachers and students to support questioning, explanation, reasoning, and the sharing of student-generated ideas (Fukawa-Connelly, 2012; National Council of Teachers of Mathematics, 2000; Stephan, 2014; Widjaja, 2012a). Students should be provided with ample opportunities to engage in mathematical dialogue. However, findings from this study indicate that social norms were far more prevalent than sociomathematical norms, which were limited to elements such as negotiation and idea sharing. Mathematics instruction was largely dominated by teacher-centered activities, where teachers explained concepts, presented example problems, and solved them in front of the class. Student participation was primarily limited to listening and occasionally assisting with calculations during teacher explanations.

The majority of teacher questions focused on computational tasks rather than conceptual understanding. These findings are consistent with observations by Putri, Dolk, and Zulkardi (2015), who noted that teachers often deliver content through direct instruction, pose closed-ended questions, and expect students to comply with predefined expectations. Hendayana (2014) similarly reported that most instructional time in mathematics classrooms is spent listening to the teacher, with minimal peer interaction. Enhancing sociomathematical norms in the classroom can be achieved by providing students with learning opportunities that involve collaborative group activities emphasizing dialogic engagement.

Teachers hold the authority to manage classroom interaction. Research on mathematics classroom interaction aims to capture the qualitative dimensions of communication that occur during instruction, particularly at the junior secondary level. The classroom can be viewed as a microcosm of school culture, shaped by its own social climate and interpersonal relationships. Mathematics instruction is increasingly oriented toward student-centered learning, as exemplified by the implementation of problem-posing pedagogy.

Throughout the implementation process, several challenges emerged. The research team and participating teachers worked collaboratively to adjust instructional practices. Together, they examined obstacles encountered during the process and reflected on necessary changes. One major concern involved managing transitions between small-group and whole-class activities. To address these concerns, discussions were held to streamline instructional steps while maintaining opportunities for the development of sociomathematical norms.

At the outset, teachers expected students to explain their reasoning and engage in mathematical disagreement. However, in practice, teachers often guided students directly toward specific answers. Many experienced a dilemma when shifting away from conventional teacher-directed instruction toward a more student-centered approach. Teachers who were accustomed to providing explicit explanations found it challenging to adopt a facilitative role that encouraged exploration of student thinking. These experiences led to joint reflection on the true goals of mathematics education—positioning students as active agents in the learning process. Building a culture of sociomathematical norms in the classroom was seen as essential, particularly through the use of questions that prompt discussion and encourage students to pose their own problems.

The teacher and research team viewed these issues as valuable challenges. The teacher demonstrated support for student-centered learning by positioning herself as an effective classroom facilitator. Through this process, the teacher developed a deeper understanding of the true nature of learning—recognizing the importance of providing all students with opportunities to express their ideas, offer constructive feedback, and formulate reasoned responses.

One notable issue involved students' mathematical explanations, which tended to emerge only when prompted by the teacher. Ideally, sociomathematical norms should foster student autonomy, enabling students to explain ideas spontaneously. However, because the instructional model remained largely directive, students still required significant teacher scaffolding to articulate their reasoning.

Mathematical difference—the emergence of diverse solutions followed by judgments about which responses are more elegant—was also limited in scope. In this study, mathematical difference primarily referred to variations in the presentation of final answers, while procedures and strategies remained the same. This falls short of the ideal, where elegant solutions emerge organically from students' comparative evaluation of alternative methods (Widodo et al., 2020; Yackel & Cobb, 1996). Nevertheless, exposure to these differences helped students build confidence in their own thinking. As long as they followed sound procedures and concepts, differing answers were not discouraged. This aligns with the well-known expression, "All roads lead to Rome."

Problem posing, as discussed by Çakır and Akkoç (2020), emphasizes students' ability to generate questions fluently, flexibly, and originally. In this study, while students were guided to construct problems aligned with the lesson objectives, they often resorted to changing numbers or altering the context of given problems—demonstrating limited fluency in problem formulation. This remains far from the ideal of genuine curiosity-driven questioning. For classrooms newly introduced to problem-posing pedagogy, such challenges are expected. Instructional strategies like the "What-If-Not" technique (Brown & Walter, 2012) may help train students to develop more meaningful and creative mathematical questions.

CONCLUSION

This study highlights two key aspects of mathematics instruction: traditional classroom teaching and the implementation of a problem-posing approach. First, traditional mathematics classrooms in Indonesia remain predominantly teacher-centered, with 86% of classroom discourse initiated by the teacher and only 14% by students. The observed norms included praying, singing national songs, asking questions, listening to explanations, and engaging in discussion. However, sociomathematical norms—such as sharing mathematical ideas and engaging in negotiation—were limited in occurrence.

The second part of this study focused on the emergence of sociomathematical norms within problem-posing classrooms. The findings revealed that students in these settings demonstrated mathematical explanation, mathematical difference, and problem posing as developing sociomathematical behaviors. Importantly, this instructional shift was carried out in collaboration with teachers, who were newly introduced to the strategies of problem posing and the underlying sociomathematical norms. This teacher learning curve represents a limitation of the study, as the findings reflect an initial trial phase rather than a mature implementation.

To fully support problem-posing pedagogy, teachers must possess strong skills in designing and facilitating problem-posing tasks, an in-depth understanding of sociomathematical norms, and effective questioning strategies that foster interactive dialogue. Future research should focus on the professional development of teachers in these areas, particularly within the Indonesian context. Considering the results of this study, Indonesia shows promising potential for implementing mathematics instruction that meaningfully integrates sociomathematical norms through the use of problem posing.

AUTHOR CONTRIBUTIONS STATEMENT

EFN was responsible for the conceptualization and design of the study, including the development of research instruments and coordination with participating schools. This author also led the classroom observations, data collection, and preliminary data analysis using NVivo. Additionally, Author 1 drafted the initial version of the manuscript, integrating theoretical frameworks and interpreting the findings in relation to sociomathematical norms and problem-posing pedagogy. **WW** and **ADS** contributed significantly to refining the research methodology, provided critical feedback during data analysis, and reviewed the coding of student–teacher interactions. This author also collaborated closely in revising the manuscript, ensuring academic coherence, and strengthening the discussion and conclusion sections. Author 2 further supported literature review development and provided guidance on aligning the findings with national curriculum standards.

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