

## **ANALYSIS OF INTERACTION PATTERNS AMONG DEAF STUDENTS THROUGH THE PEER TUTOR METHOD IN MATHEMATICS LEARNING**

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### **ABSTRACT**

Deaf students have characteristics of learning mathematics that are highly dependent on visual channels due to limited linguistic and sensory access, so that abstract mathematics learning often becomes a challenge. The mismatch between these characteristics and teachers' delivery of material that is predominantly verbal or uses complex language structures results in less effective learning communication. This study aims to gain an in-depth understanding of the patterns and dynamics of interaction among deaf students during the application of the peer tutoring method in mathematics learning, particularly in flat geometry. The research used a qualitative approach with a case study design involving 16 deaf students at SLB-B YPPALB Magelang City from elementary to high school levels, divided into four heterogeneous groups based on the level of hearing impairment, additional disabilities, and peer tutor roles. Data were collected through structured classroom observation, learning documentation, and semi-structured interviews, then analyzed through data reduction, data presentation, and conclusion drawing stages. The results showed that interactions between students through peer tutors were more intensive and effective than interactions between students and teachers. These findings are in line with Vygotsky's Social Constructivism theory, which emphasizes the role of social interaction and peer scaffolding in learning. Peer tutors function as linguistic and social mediators through sign language, gestures, and concrete representations, thereby facilitating the understanding of mathematical concepts. The dynamics of interaction are influenced by the degree of hearing loss, additional disabilities, and the communication skills of peer tutors. These findings recommend that mathematics learning for deaf students be strategically designed based on peer tutoring to improve interaction, participation, and conceptual understanding.

**Keywords:** Deaf Students, Peer Tutor, Social Interaction, Mathematics Learning, Inclusive Education.

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### **PRELIMINARY**

Deaf students possess distinctive characteristics in learning mathematics, which are shaped by limited linguistic and sensory access. These characteristics lead them to rely more heavily on visual channels rather than auditory input when receiving academic information (Barwell et al., 2016; Blatto-vallee et al., 2007). Consequently, the abstract

nature of mathematics often presents significant challenges. Mathematics requires logical reasoning, symbolic understanding, and abstract thinking (Maulyda et al., 2020), whereas deaf students tend to comprehend information more effectively when it is concrete, visual, and supported by real representations (Suarsana, 2021). This tendency does not always align with the way teachers deliver mathematical content, leading to less effective communication in the classroom.

Difficulties arise when teachers deliver explanations verbally or through complex linguistic structures. The spoken language used by hearing teachers often does not align with the sign language patterns or linguistic structures used by deaf students (Aziz & Agustina, 2021; Prinzi, 2023). As a result, a communication gap emerges, causing students to lose conceptual meaning and experience obstacles in constructing mathematical understanding. In principle, based on Article 5 paragraph (1) of Law Number 8 of 2016 that deaf students have the right and ability to obtain learning opportunities equal to those of hearing students. However, gaps persist, indicating that linguistic barriers and the lack of adapted communication strategies prevent deaf students from fully accessing mathematics learning equitably (Bashir et al., 2024). Therefore, a communication bridge is needed to connect the teacher's language with the students' comprehension, namely through interactions among deaf peers. Deaf students who better understand the material can re-explain it to their classmates using sign language, visualizations, or more accessible expressions (Gerald & Joseph, 2025; Papen & Gillen, 2022).

As a learning strategy that emphasizes collaboration and peer support, the peer tutor method offers a potential solution to communication challenges in mathematics learning for deaf students. Peer tutoring is a strategy in which students take responsibility for teaching and assisting the assessment of their peers (Bell et al., 2023). Within this approach, students who have a stronger grasp of the material help peers who experience difficulties (Burgess et al., 2016). Peers are able to use simpler linguistic structures or nonverbal media that are easier for deaf students to understand, enabling them to access alternative explanations beyond those provided by the teacher (Aziz & Agustina, 2021; Iturriaga, 2025). Collaborative approaches such as peer tutoring thus represent a promising instructional option for overcoming barriers in direct teacher–student communication, while also fostering a more inclusive and supportive learning environment.

Peer tutors provide academic guidance or support to their classmates with the aim of mutually assisting in understanding specific subject matter or skills, either individually or in groups (Korpela et al., 2023). In the context of deaf students, peer tutoring can

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function as a communication bridge by explaining mathematical concepts through more familiar linguistic styles, visual media, or slow and repetitive approaches that align with their peers' comprehension abilities (Aftab et al., 2024; Putranto et al., 2022). Recent studies indicate that implementing the peer tutor method in mathematics learning for deaf students can enhance their understanding and engagement (Anditiasari et al., 2023). By learning together in a more relaxed and supportive environment, deaf students are more likely to grasp mathematical concepts gradually through friendly and accessible interactions.

Peer interaction is a dynamic process that involves social behaviors, social status, and friendship relationships, in which individuals connect with one another, exert mutual influence, and build reciprocal relationships within social and emotional contexts ((Batten et al., 2013; Järvenoja et al., 2025). Interaction fostered through peer tutoring enables deaf students to support one another and learn collaboratively in understanding mathematical concepts. Peer tutors can provide immediate feedback, assist classmates who encounter difficulties, and create a more communicative learning environment (Redzimska & Sulikowski, 2024). Thus, the peer tutor method functions not only as an academic instructional strategy but also as a medium for building positive social interactions among deaf students in the classroom (Redzimska & Sulikowski, 2024; Sheza Amjad & Muhammad Usman Zia, 2025). The interactions developed throughout the learning process are expected to enhance engagement, mutual understanding, and collaboration, thereby supporting the achievement of mathematics learning objectives.

Although numerous studies have examined mathematics learning and the use of peer tutoring among deaf students, several research gaps remain unaddressed. Research of Krause (2023) investigated the use of multimodal communication in the education of deaf learners, yet the study did not analyze how peer interaction contributes to the construction of mathematical understanding. Research of Kamilah (2025) demonstrated that peer tutoring improves the mathematics learning outcomes of deaf students; however, the study focused primarily on learning results rather than the dynamics of interaction, visual communication strategies, or forms of peer support that occur during the learning process. Meanwhile, Morai (2025) highlighted peer tutoring as one of the strategies used in inclusive education for students with hearing impairments, but did not examine how specific interaction patterns among deaf students emerge when sign language is used as their primary mode of communication.

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These findings indicate that no prior research has specifically and comprehensively examined the interactions among deaf students during the implementation of the peer tutor method in the context of mathematics learning, particularly on the topic of plane geometry. Furthermore, existing studies still tend to place the peer tutor method as a learning strategy only, without examining in depth the social interaction and communication processes that occur between deaf students during mathematics learning. Thus, this study offers a novel contribution by providing a comprehensive analysis of the interaction, communication, and collaboration dynamics that emerge among deaf students during peer-tutoring activities

Therefore, interaction among deaf students through the implementation of the peer tutor learning method is not only essential for ensuring equitable learning opportunities but also represents an important step toward more inclusive and effective mathematics instruction (Herring & Woolsey, 2020; Paatsch et al., 2022). By taking into account the visual communication characteristics and social needs of deaf learners, peer-tutor-based instruction becomes a strategic approach for creating more interactive and meaningful learning experiences, thereby strengthening the depth and quality of mathematical learning.

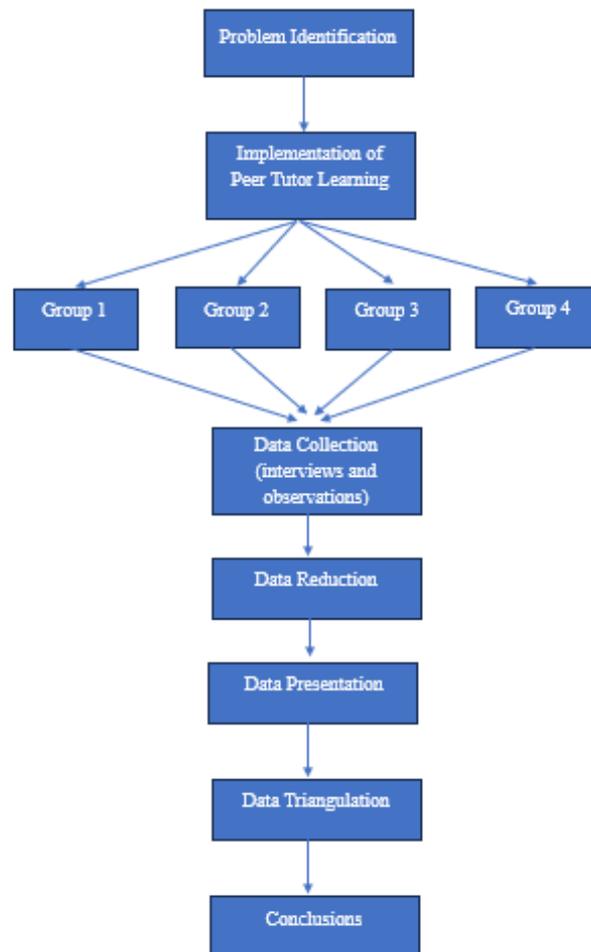
This study focuses on a comprehensive analysis of the fundamental aspects of interaction that occur among deaf students during the implementation of the peer tutor method, particularly within the context of plane geometry instruction. The study is expected to contribute not only to improving the quality of mathematics learning for deaf students but also to enriching the broader discourse on inclusive education by emphasizing the central role of social interaction in the learning process. This comprehensive investigation is essential for fostering an educational environment that is equitable, communicative, and supportive for all learners, regardless of their limitations or differences in ability.

## **METHODS**

This study employed a qualitative method with a case study design. A case study is a research approach that investigates one or several bounded cases (individuals, groups, organizations, or programs) in depth and within their real-life context by utilizing multiple sources of data, with the aim of obtaining a comprehensive and thorough understanding of complex phenomena (Crowe et al., 2011; Heale & Twycross, 2018; Pickard, 2018). The purpose of this study is to gain an in-depth understanding of the patterns and dynamics of interaction among deaf students during the implementation of the peer tutor learning method in mathematics, particularly in the topic of plane geometry. Data analysis

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techniques included data reduction, data display, conclusion drawing, and verification (Miles, Huberman, & Saldaña, 2014). The validity of the research findings was ensured through credibility, confirmability, dependability, and transferability criteria (Moloeng, 2016). The stages of the research process are illustrated in the flowchart presented in Figure 1.



**Figure 1. Research Flowchart**

The study was conducted at SLB-B YPPALB in Kota Magelang using a purposive sampling technique that was implemented in a contextual and availability-based manner, in which research participants were intentionally selected based on specific criteria. The participants included students with mild to profound hearing loss, some of whom also experienced intellectual disabilities, resulting in diverse communication patterns and interaction abilities during mathematics learning through peer tutoring. The sample consisted of 16 deaf students who actively participated in mathematics learning and were directly involved in peer-tutoring activities, representing varying degrees of hearing loss mild, moderate, and severe along with additional learning barriers, ranging from Grade 6

of primary school to Grade 10 of senior high school. The research instruments consisted of interview guidelines and an observation sheet used to document student interactions across several aspects: generating ideas, creativity, peer discussion, and discussion with the teacher. The participants were divided into four groups based on the degree of hearing loss, intellectual characteristics, additional special needs, and their respective roles within the peer-tutoring learning process, as presented in Table 1 below.

**Tabel 1. Characteristics of Hearing-Impaired Students**

| <b>Groups</b> | <b>Characteristics</b>  | <b>Class</b>                            |
|---------------|---|---|
| 1             | S1: Medium-level deaf students<br>S2: Medium-level deaf students<br>S3: Medium-level deaf students with autism spectrum disorder<br>S4: Heavy deaf students with intellectual disabilities<br>S5: Heavy deaf students acting as peers     | Sixth grade of elementary school        |
| 2             | S1: Students with a heavy hearing impairment<br>S2: Students with a heavy hearing impairment and intellectual disability<br>S3: Students with a heavy hearing impairment acting as peers  | 10th grade of high school               |
| 3             | S1: Students with a heavy hearing impairment<br>S2: Students with a heavy hearing impairment acting as peers<br>S3: Students with a heavy hearing impairment and intellectual disability<br>S4: Students with a medium hearing impairment | 7th grade of junior high school         |
| 4             | S1: Students with deafness acting as peers<br>S2: Students with mild deafness<br>S3: Students with severe deafness and intellectual disabilities<br>S4: Students with mild deafness and intellectual disabilities                         | 8th and 9th grade of junior high school |

## **RESULT AND DISCUSSION**

The implementation of the peer tutor model in mathematics learning on flat plane geometry material plays an important role in enhancing interaction and participation among hearing-impaired students. Interaction in the educational context is a reciprocal process between students, teachers, and the learning environment, involving the exchange of ideas, feelings, and experiences to achieve learning objectives (Mulyana & Restendi, 2022). According to Vygotsky (1978), cognitive development is formed through social interaction because knowledge is actively constructed through communication and collaboration. In the learning process, activities such as exchanging ideas, providing feedback, and working together become important means to build meaning and students'

conceptual understanding. The peer tutor model functions not only as an academic strategy but also as a social interaction forum that supports the cognitive development of hearing-impaired students.

Based on classroom observation data, the teacher facilitated the learning activities by providing concept explanations and forming heterogeneous groups. The explanation of concepts was delivered through concrete media and visual communication such as sign language, body movements, and facial expressions. This strategy not only served as a means of conveying information but also functioned as a form of linguistic adaptation that accommodates students' auditory limitations. The formation of heterogeneous learning groups by placing one to two peer tutors in each group created a balanced interaction dynamic. Peer tutors acted as linguistic mediators and direct sources of feedback for other students who had difficulty understanding the teacher's instructions. This role enriched the two-way communication process while shifting the learning orientation from teacher-centered to peer-mediated.



**Figure 2. Active Peer-Tutoring Learning Environment**

In general, the learning activities show that the peer-tutoring model is able to create a collaborative, inclusive, and supportive learning atmosphere. Students demonstrated increased engagement in understanding the shapes and properties of plane figures through visual interaction and group discussions. This engagement was not merely mechanical but reflected the development of students' sense of agency and confidence in constructing knowledge independently.

However, the dynamics between groups showed differences in participation intensity. Some groups displayed high levels of communication activity, while others were relatively passive.

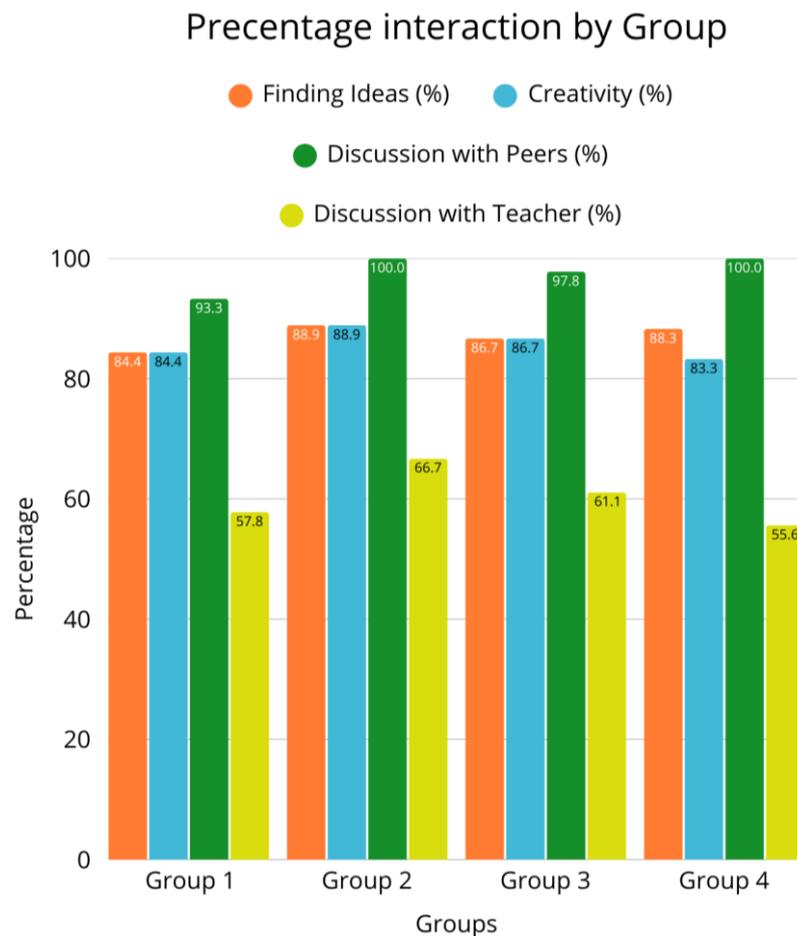
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**Figure 3. Passive Group in Peer-Tutoring Learning**

Figure 3 shows that students in Group 1 tended to be more passive in responding to the tutor's instructions. Their interaction was limited to simple visual communication, with low frequency of asking questions or expressing opinions. This condition may be influenced by a higher degree of hearing loss, differences in cognitive abilities among group members, as well as the presence of specific impairments within the group. This situation reinforces Moores' (2010) view that the learning characteristics of deaf students greatly depend on visual communication support and a conducive social environment.

Based on the results of the frequency analysis of the four interaction aspects generating ideas, creativity, peer discussion, and discussion with the teacher variations in participation levels across groups were observed. The assessment was conducted using a three-level scale: rare (1), occasional (2), and frequent (3). Scores were obtained from classroom observation data and processed using frequency analysis to map the level of student engagement across groups. This analysis is presented in Figure 4 below.



**Figure 4. Comparison of Interaction Aspects per Group**

The data show that the aspect of peer discussion achieved the highest percentage across all groups, ranging from 93.3% to 100%, with the highest levels observed in Groups 2 and 4. This indicates that interaction among students is the most effective communication channel in the learning context of deaf students. This activity provides space for students to exchange ideas, confirm their understanding, and validate problem-solving strategies in a more egalitarian manner.

Conversely, the aspect of discussing with the teacher showed the lowest percentage (55%–67%), confirming a tendency for students to rely more on peer communication than on teacher authority. This phenomenon aligns with research of Hodayouni (2022) findings through the lens of Vygotsky's Social Constructivism theory, which posits that peer interaction plays an essential role as scaffolding that supports cognitive development through language and social mediation. In the context of deaf students, this function is further reinforced by the use of visual communication, which is more easily accessible to them.

The aspects of generating ideas and creativity show average values ranging from 83% to 89%. These results reflect that peer tutoring activities not only enhance social skills but also facilitate divergent thinking processes. Students learn to express ideas and experiment with problem solving strategies using visual representations an approach that is crucial for learners with auditory impairments.

More specifically, Group 2 demonstrated the highest overall performance, supported by the active role of peer tutors who possessed strong visual communication skills and the ability to restate concepts in simple terms. Group 3 ranked next with a high level of collaboration and balanced interaction among group members. Group 1, which consisted of students with additional challenges such as autism and speech impairments, showed the lowest level of interaction, while Group 4 fell into the high category due to tutors who were patient and adaptive in providing individualized support.

These findings are consistent with the results of Burgess et al. (2016) dan Bell et al. (2023), who assert that peer-tutoring-based learning can strengthen social engagement, self-confidence, and academic independence among students with special needs. In addition, the perspectives of Moores (2010) with Marschark and Hauser (2012) reinforce the interpretation that deaf individuals rely on visual modalities as the primary channel for constructing meaning. Therefore, peer-interaction-based strategies that prioritize visual communication hold strong pedagogical relevance in mathematics learning, especially for abstract concepts such as geometry.

Theoretically, these results are also in line with the Visual-Spatial Learning theory (Paul & Whitelaw, 2011), which emphasizes the importance of concrete and collaborative representations in helping students understand symbols and spatial relationships. However, the results of this study also expand the application of this theory by showing that the effectiveness of visual learning does not only depend on the presentation of spatial representations individually, but also on social and collaborative interactions between deaf students. In this context, the application of the peer tutor method serves as a medium for transforming abstract concepts into contextual and meaningful learning experiences through peer mediation. These findings indicate that visual-spatial learning becomes more optimal when combined with a peer-tutored communication structure that allows for the exchange of meaning, clarification of concepts, and collective validation of understanding. Thus, this study reinforces the Visual-Spatial Learning theory in the framework of inclusive education by emphasizing that effective visual learning for deaf students is

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social, dialogical, and integrated with peer interaction, not merely an individual cognitive process (Aftab et al., 2024; Graham et al., 2021).

Overall, the findings of this study indicate that the implementation of the peer-tutoring model in mathematics instruction for deaf students is not only effective in increasing interaction frequency but also contributes to the development of visual communication skills and social cohesion within the learning group. This model is worthy of consideration as an inclusive pedagogical approach that places collaboration and visual communication at the core of the learning process, in line with the direction of inclusive education policy and the principles of student-centered learning.

## **CONCLUSION**

Based on the research objective to analyze the patterns and dynamics of interactions among deaf students in the application of the peer tutor method in mathematics learning, particularly in flat geometry, it can be concluded that peer-to-peer interaction is the most dominant and effective interaction pattern. The research findings show that peer discussions had the highest percentage (93–100%) compared to student-teacher interactions, which tended to be lower (55–67%). This confirms that deaf students are more active, responsive, and confident when interacting with friends who have similar sensory and linguistic characteristics.

The dynamics of interaction formed in peer tutor-based learning show that peer tutors act as linguistic and social mediators, bridging the communication gap between teachers and deaf students. Through the use of visual communication, sign language, gestures, and concrete representations, peer tutors help students understand flat geometry concepts more meaningfully. This interaction not only supports cognitive understanding but also encourages collaboration, the courage to express ideas, and active involvement in the learning process.

In addition, this study shows that the patterns and intensity of interaction vary between groups, influenced by the degree of deafness, the presence of additional barriers, and the visual communication skills of peer tutors. Groups with adaptive and communicative peer tutors showed more balanced and participatory interaction dynamics, while groups with double barriers tended to show more limited interactions.

Thus, it can be concluded that the peer tutor method not only functions as an alternative learning strategy but also as an effective inclusive pedagogical approach in building social interaction, visual communication, and collaboration among deaf students

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in mathematics learning. These findings reinforce Vygotsky's social constructivism view that learning occurs optimally through social interaction, and provide empirical contributions to the development of more communicative, participatory, and deaf student-centered mathematics learning practices.

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