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Mathematics Learning for Deaf Students: A Case Study in an Inclusive Classroom

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Abstrak

Siswa tuli menghadapi tantangan signifikan dalam mempelajari matematika, sebuah mata pelajaran yang sangat bergantung pada komunikasi verbal dan konsep abstrak. Pendidikan inklusif bertujuan untuk menciptakan lingkungan yang mendukung semua siswa, termasuk mereka yang memiliki perbedaan fisik dan kognitif. Penelitian ini bertujuan untuk mendapatkan pemahaman yang lebih dalam tentang cara pengajaran matematika bagi siswa tuli dalam pengaturan kelas inklusif, termasuk bagaimana kurikulum matematika disesuaikan untuk memenuhi kebutuhan siswa tuli yang terkait dengan tantangan terjemahan dan akses kognitif. Penelitian ini dilakukan di Kelas 12B di SMA Tumbuh, Yogyakarta, tahun ajaran 2023-2024. Penelitian ini menggunakan pendekatan deskriptif kualitatif dan dirancang sebagai studi kasus. Kelas ini terdiri dari delapan siswa: lima siswa reguler, satu dengan gangguan kecemasan, dan dua siswa tuli. Selama satu tahun, data dikumpulkan melalui observasi kelas, wawancara mendalam dengan support teacher, wawancara dengan siswa Kelas 12B, dan diskusi dengan guru matematika lainnya untuk mendapatkan wawasan lebih luas mengenai pendekatan pengajaran di berbagai kelas. Temuan menunjukkan bahwa pengajaran di Kelas 12B berakar pada nilai-nilai inklusif. Guru menyesuaikan pembelajaran dengan kebutuhan individu setiap siswa. Guru membedakan pembelajaran dengan variasi kedalaman materi, memilih contoh yang relevan, menyediakan latihan yang berbeda, dan menyesuaikan penilaian. Upaya ini mendukung siswa dengan kebutuhan pembelajaran dan kebutuhan khusus untuk terus aktif dalam proses pembelajaran.

Abstract

Deaf students face significant challenges in learning mathematics, a subject heavily reliant on verbal communication and abstract concepts. Inclusive education aims to create an environment that supports all students, including those with physical and cognitive differences. The current study, therefore, sets out to gain a deeper understanding of how mathematics for deaf learners is enacted within an inclusive classroom setting, including how the mathematics curriculum is adapted to serve the needs of deaf learners in response to translation and cognitive access challenges. The study was conducted in Class 12B at Tumbuh Senior High School, Yogyakarta, in the 2023-2024 academic year. This study uses a qualitative descriptive approach and is framed as a case study. The class includes eight students: five are typical learners, one has an anxiety disorder, and two are deaf. Over a year, data were gathered through classroom observations, in-depth interviews with the support teacher, interviews with students from Class 12B, and discussions with other math teachers to gain broader insight into teaching approaches across classrooms. The findings show that teaching in Class 12B is rooted in inclusive values. Teachers are able to customize lessons to the individual needs of each student. Instead of a one-size-fits-all approach, the teacher differentiates learning by varying the depth of the content, selecting relatable examples, providing different exercises, and adjusting assessments. These efforts support students with unique learning and special needs to continue participating in the learning process.

INTRODUCTION

Learning mathematics is not always straightforward, and for students who are deaf, the experience can be particularly demanding. Unlike subjects that rely more on visual materials, mathematics is often taught through spoken explanations and abstract reasoning. Both of which may not be easily accessible to students who cannot hear. Interestingly, deaf students generally possess average or even above-average intelligence. However, their cognitive development is deeply influenced by how they acquire language. When language access is limited, they may struggle to build vocabulary, interpret figurative language, or understand abstract concepts, all

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of which are foundational in learning math (Leton, Wahyudin, & Darhim, 2018). It is not just about language either. As Serrano Pau (1995) points out, there's a strong link between reading comprehension and mathematical problem-solving, another reason why instructional accessibility matters so much.

Even so, we should be careful not to focus only on the challenges. Deaf students also bring strengths into the classroom, particularly their heightened visual processing skills, which can actually support learning when teaching strategies are adapted accordingly (Nunes, 2002). In this context, inclusive education becomes more than just a philosophy. It becomes a practical necessity. At its core, inclusive education believes that all students, regardless of ability, deserve to learn side by side. But making that possible requires more than just placing everyone in the same room. It calls for thoughtful teaching approaches that meet a wide range of learning needs.

One such approach is differentiated instruction, a method that allows educators to tailor what and how they teach based on each student's readiness, interests, and ways of learning (Russo, Sullivan, & Bobis, 2021). It is not a rigid formula. It is flexible. It invites teachers to look at their students as individuals with distinct learning profiles, and to design lessons that reflect that.

Inclusive classrooms also echo the principles of multicultural education, where diversity is not seen as a hurdle, but as a valuable presence in the room. it is about building a classroom culture where students come to understand and appreciate differences, whether in language, background, or learning style (Shernoff et al., 2011). And yes, this can be challenging for teachers. But the goal is clear, sush as to provide instructional materials, classroom support and assessments that allow each student to grow.

Differentiation plays a crucial role here. As Tomlinson (cited in Kusuma & Luthfah, 2020) describes, it is about giving students multiple pathways to engage with content, process information, and demonstrate what they have learned. It doesn't mean creating a separate lesson plan for every student. Rather, it involves intentional planning using varied groupings, flexible pacing, and meaningful choices. Faiz (2022) adds that differentiation works best when it is proactive, not reactive.

Understanding the types of hearing loss also helps. Deafness is not one-dimensional. It can be conductive, sensorineural, or mixed (Gabriel, 1988). Each type comes with its own implications, and knowing this can guide educators in supporting their students more effectively.

Studies back this up. Smale-Jacobse et al. (2020) found that when teachers adjust instructional content and processes, students with a wide range of needs can participate more meaningfully. Differentiation, in this sense, becomes a way to open doors, not just accommodate. Meanwhile, Broderick, Mehta-Parekh, and Reid (2023) remind us that inclusion is not just about the curriculum. it is also about the classroom climate, how teachers communicate, how students work together, and how everyone feels they belong. Their work highlights practices like co-teaching, using scaffolds, and applying multimodal instruction.

Molder (2024), in a more recent review, also emphasizes that no single teaching method works for all. For students with auditory impairments, success often lies in using a combination of visual aids, peer interaction, and sign language support. it is not only *what* taught, but also *how*, *by whom*, and *with* what sensitivity.

Now, let's talk about mathematics. For deaf students, learning math in a general education setting can be tough, especially when explanations are mostly verbal. At Tumbuh Senior High School in Yogyakarta, inclusive education is more than an ideal, it is a daily reality. Here, students with various needs, including deaf learners, study alongside their peers. This environment calls for creative and adaptive teaching strategies. Mathematics teachers in this context have to go beyond traditional methods. Visual models, interactive activities, and clear, structured communication become essential (Luckner, 1994).

This study sets out to explore how differentiated instruction is applied in inclusive mathematics classrooms at Tumbuh Senior High School, with a specific focus on the experience of deaf students. By investigating how teachers design and implement inclusive strategies, the research hopes to offer useful insights, both practical and theoretical. Ultimately, it aims to

contribute to a larger conversation about how schools can create fair, responsive, and empowering learning spaces for all students.

METHODS

This research was a case study using a descriptive qualitative method. The purpose of this study was to describe the implementation of inclusive mathematics learning with deaf students. The research was conducted in class 12B of Tumbuh Senior High School Yogyakarta for one year, namely in the 2023-2024 academic year. Class 12B consisted of 8 students, with a breakdown of 5 regular students, 1 student with an anxiety disorder, and 2 deaf students. Class 12B was an international class at Tumbuh Senior High School. Mathematics learning in this class used the Cambridge curriculum and was conducted in English. In this research, the researcher was the mathematics teacher in class 12B. During the learning process, the teacher was assisted by a support teacher to facilitate communication with deaf students. Data was collected through observation for one year, interviews with the support teacher, interviews with 12B students, and interviews with mathematics teachers who taught in other classes at Tumbuh Senior High School to compare with the conditions of other classes.

RESULTS AND DISCUSSION

Inclusive Education at Tumbuh Senior High School

Tumbuh Senior High School in Yogyakarta built a reputation for being a school that welcomed everyone. Its approach to inclusive education was not just a label. It was part of the daily rhythm of school life. Students with and without special needs learned together in the same classrooms, sat side by side, and completed tasks together. The school's guiding vision was clear: to help children grow into learners who cared about the environment, loved their country, and were ready to compete in a global world.

This vision was not just written on a poster. It was reflected in how the school organized its classrooms and programs. Rather than placing students in separate spaces based on ability, the school brought them together. The idea was simple: learning was better when it happened through interaction and shared experience. Students with special needs benefited from being part of the regular classroom. At the same time, their peers learned empathy, patience, and the value of diversity.

Students with a wide range of learning profiles were supported here. Some had autism, some dealt with ADHD, others experienced anxiety or learning difficulties. Several students had hearing impairments, including four deaf students that academic year. The range of hearing ability varied, some could use hearing aids effectively, while others could not. But these differences did not limit potential. Two of the deaf students were particularly skilled in the performing arts. Their ability to move with rhythm and emotion, even without hearing the music, surprised and inspired many. It showed how talent could shine through in ways that were not always expected.

Inclusion at this school was not limited to academics. Students took part in extracurricular activities, events, and performances. They were encouraged to contribute, create, and collaborate. Learning was adapted when needed. Teachers modified materials or changed how lessons were delivered to make sure no one was left out. Group work was common, and students were often placed in mixed teams, creating chances for natural interaction and cooperation.

Teachers at Tumbuh received training on how to teach inclusively. They learned how to recognize different learning needs, how to adjust instruction, and how to support students without making them feel different. There were also special support teachers. These educators acted as bridges, helping students with special needs connect with the wider class, especially in subjects where they may have struggled to follow along.

For deaf students, communication support was crucial. Some support teachers knew sign language and used it in class. They also helped other students learn basic signs, like finger spelling. This way, communication did not only depend on adults, students learned to connect with one another too. It created a sense of belonging, which, as any teacher knew, was just as important as test scores.

The school's approach was broad but personal. It was about giving each student the chance to succeed in their own way. At the same time, it was about shaping a school culture that valued kindness, respect, and shared effort. The goal was not only academic achievement, but also building young people who understood difference, and who were ready to live and work in a world that was rarely uniform.

Curriculum Implementation and Adaptation

At Tumbuh Senior High School, two curricula were applied in parallel: the national Merdeka Curriculum and the Cambridge International Curriculum. The latter was used specifically in international classes, including Class 12B (the focus of this study). Instruction in these classes was carried out entirely in English, which brought a unique set of challenges, especially for students whose educational background was grounded in the Indonesian-language national system.

For many of these students, the shift was not just about switching to a different set of materials, it was a cognitive leap. They were expected to process mathematical concepts, some of which were quite abstract, in a language that was not their mother tongue. As one teacher put it during an informal discussion, "Sometimes they understood the math, but the language got in the way." This observation pointed to a gap that could not be ignored.

To support students through this transition, the school did not merely rely on rigid curriculum delivery. Teachers adapted their methods constantly. The Cambridge syllabus acted more as a reference than a fixed structure. Teachers simplified instructions when needed, rephrased questions, and broke down problems into manageable parts. Occasionally, they also slipped into Bahasa Indonesia during key explanations, particularly when a student was visibly struggling.

Rather than overwhelming students with a rigid pace, the content was scaffolded. New ideas were introduced gradually. Teachers assessed how well students were coping before moving on. If a concept did not land, it was revisited. The pacing was flexible, not everyone moved at the same speed, and that was okay. Those who needed more time were supported, while those who were ready were challenged further. This philosophy underlay much of the differentiated instruction applied across the school.

In classrooms like 12B, instructional flexibility was not just a good idea, it was essential. The students brought different experiences, different needs, and different ways of learning. Some grasped mathematical ideas quickly; others needed more time and visual support. And for the deaf students in particular, the usual methods of teaching simply did not work the same way.

Most math classes, almost by default, relied on a lot of talking. Teachers explained concepts, gave examples verbally, walked through problems aloud. For hearing students, that was fine. But for students who could not fully follow spoken instructions, either because of hearing limitations or language barriers, something had to change.

That was where the support teachers came in. In Class 12B, they often sat close to the deaf students, ready to step in when clarification was needed. They used sign language, handwritten notes, and visual examples to help bridge the gap. One of the support teachers mentioned that they often "rebuild" the lesson in simpler terms, sometimes even after class, just to make sure the concept stuck.

The classroom itself started to evolve too. You saw more visuals on the whiteboard, color-coded steps, diagrams, flowcharts. Teachers used tools like animated graphs or math apps, not for the sake of being modern, but because some students simply needed to see things to understand them.

There was also a lot of emphasis on collaboration. Deaf students were not left to work alone unless they chose to. Instead, peers were encouraged to include them, explaining things through gestures, writing on shared paper, or using simple signs they had picked up over time. This sort of peer-to-peer learning was not formalized, but it worked. It built understanding and a sense of connection.

Assessment, also got a personal touch. Traditional tests, especially ones packed with wordy instructions, did not always reflect what these students knew. So teachers tweaked the

format. They included diagrams, simplified the language, or walked through problems together with the student. In some cases, teachers held brief oral reviews using gestures or drawings to see how much a student really understood. It was less about ticking boxes and more about making sure the concept was truly there.

Mathematics Learning in Class 12B

Class 12B was far from uniform. It was a small group, but every student brought something different to the table. Among them were five students who followed the curriculum without needing major adjustments, one student managing an anxiety disorder, and two deaf students, let's call them Respondent A and Respondent B for the sake of this study.

The student with anxiety participated actively most days. On others, they might have needed to step away, turn in work late, or even miss class entirely. Teachers had learned to read the signs. They did not press, but they checked in. And when needed, accommodations were made, such as quiet corners, flexible deadlines, or short verbal check-ins instead of written work.

Now, about the two deaf students. Respondent A was confident in sign language and seemed at ease in class discussions. They took notes diligently, asked questions when something was unclear, and generally moved through the lessons with solid engagement. But math was not only about following steps, it often demanded abstract reasoning, especially at this level. That was where Respondent A sometimes hesitated. For multi-step problems or abstract functions, a gap appeared. Not due to lack of effort or intelligence, but because many of those ideas were still taught verbally, in a format that was not always easily translated through sign.

Visual supports helped. When problems were broken into smaller chunks, shown as diagrams, or modeled through step-by-step scaffolds, comprehension improved. Peer collaboration helped too; when classmates were patient and open, the flow of understanding seemed to come faster.

Respondent B, however, presented a different learning profile. They did not use sign language and relied mostly on lip-reading, which itself required intense focus. Academically, they were behind, about three years older than the rest of the class. It was not for lack of trying. Most of their earlier education focused on communication basics rather than content mastery.

Their vocabulary was limited, and so was their grasp of abstract mathematical relationships. But they thrived with repetition. When tasks were broken down clearly, one operation per step, with visuals and simple language, they followed. They preferred routine. A worksheet with a familiar format, predictable structure, and minimal surprises allowed them to engage with less anxiety. The goal, as their support teacher explained, was not speed or complexity, it was consistency.

Although Class 12B followed the Cambridge International AS & A Level Mathematics syllabus, what happened inside the classroom did not always mirror the textbook. Teachers here worked with the real students in front of them, not an idealized group. The curriculum was split into three main strands: Pure Mathematics 2 and 3, along with Probability and Statistics 1. But how those topics were delivered often depended on the learners' readiness and day-to-day responsiveness.

Classes were scheduled twice a week. Tuesdays were for Pure Math, while Thursdays were dedicated to Stats. But even this timetable was flexible. If students were still struggling with a concept from the previous session, teachers did not rush. There was an unspoken agreement: understanding mattered more than covering every page of the syllabus.

For deaf students especially, scaffolding was non-negotiable. Concepts were introduced slowly and reinforced through repetition. Lessons often included step-by-step demonstrations, real-world applications, and visual mapping of formulas or problems. For instance, when teaching vectors or probability trees, diagrams were not just helpful, they were necessary. Without them, some learners would have been left behind before the lesson even started.

Real-life context played a big role too. Teachers tried to link math to situations that students were familiar such as shopping, weather predictions, even simple games. For deaf students, this helped ground abstract numbers in the concrete world they interacted with. A

lesson on permutations might have started with arranging colored blocks, not just a formula on the board.

Assessment was approached just as thoughtfully. One-size-fits-all tests rarely worked. Traditional math exams, with dense text, long word problems, or heavy reliance on written instructions, could be a barrier for students like Respondent B. So teachers diversified. They used visual formats, created tiered problem sets, and even designed hands-on tasks that let students show their reasoning without needing to decode paragraphs of instructions first.

Sometimes, assessments were done in person. A student might have walked a teacher through a problem using gestures, visual supports, or even manipulatives. These one-on-one check-ins were not formalized in any grading policy, but they were often the best way to understand what a student actually knew.

It was not perfect. It took more time. It took more patience. But it was working, slowly but surely. Students, especially those with learning barriers, felt seen. And in many ways, that was the point of all of this.

Differentiated Instruction for Deaf Students

Class 12B was a small class, but honestly, each student brought something different. Respondent A and Respondent B, the two deaf students, needed their own ways of learning. Even though both had hearing issues, they approached learning in totally different ways.

Respondent A was comfortable with sign language and kept up with the class when visuals were involved. They were engaged, asked questions when they did not get something, and generally stayed on track. But when the teacher spent a long time talking, especially about abstract ideas, things got harder to follow. To help them out, teachers provided written notes, visual aids, and simplified explanations. That way, Respondent A could follow along better.

Now, Respondent B was a bit different. They did not use sign language and mostly relied on lip-reading, which was a lot for them to handle. Academically, they were behind a little, and their vocabulary was not the same as the other students. They struggled with abstract math. But they did well when tasks were broken down step-by-step, and when things were repeated until they understood. It was not about rushing through things; it was about mastering each small step at a time.

A huge part of what worked for both of them was the support teacher. This teacher knew sign language and acted like a bridge, not just between the deaf students and the teacher, but between them and everyone else in the class. The support teacher helped during lessons and spent extra time after class explaining things again. It was not just about academics; they were there emotionally too, helping the students when they felt stuck or frustrated.

To make sure everyone felt part of the class, hearing students were encouraged to learn a bit of sign language too. It started with something simple like the alphabet. It created a space where everyone could talk to each other, and it helped the deaf students feel like they belonged. Plus, it sent the message that communication was everyone's responsibility, not just the teacher's.

Interestingly, while the math teacher was not fluent in sign language, they still found ways to communicate with Respondent B. They used clear lip movements, gestures, and wrote down instructions. It was not perfect, but it worked. Over time, things like pointing, eye contact, and quick sketches on the board became part of the normal routine.

Visual aids became so important for both students. Teachers used color-coded worksheets, diagrams, and even digital tools to help explain math. These tools made abstract ideas easier to understand because the students could see them, not just hear about them.

At the end of the day, the real success was not just the tools or the visual aids. It was about how teachers kept adapting. They tried different things, watched how students responded, and adjusted when they needed to. It was not about sticking to the same plan, it was all about being flexible. That flexibility, more than anything, made the inclusive classroom in 12B feel real.

Challenges and Future Directions

While the school had made meaningful strides toward inclusion, several challenges remained, especially in mathematics. One of the hardest hurdles was teaching higher-order

thinking skills. Concepts like abstraction, logic, and multi-step problem solving were tough for many students, but for deaf learners, they came with added layers of difficulty.

A lot of math instruction was language-heavy. It relied on nuanced explanations, verbal scaffolding, and the flow of a teacher thinking out loud. When students did not have full access to that language, the deeper layers of understanding were hard to reach. Even with strong visuals, some ideas, like proofs or probabilistic logic, required sustained linguistic exposure that deaf students might not have had yet.

Support teachers were essential here, but they faced limitations of their own. Many were skilled communicators and caring guides, but not all had a strong foundation in advanced math. This meant that while they could assist with basic tasks, their ability to support topics like trigonometry or combinatorics was limited. It created a gap, not in willingness, but in content knowledge. One teacher mentioned, "Sometimes I just hoped the student copied the formula correctly, because I could not explain the why, the reason, behind it."

This was not a failure, it was a training issue. Support teachers needed ongoing professional development that included both pedagogy and math-specific content. A strong collaboration between subject teachers and support teachers could have helped bridge this gap, ensuring that deaf students received both communication support and conceptual clarity.

Classroom management was another constant balancing act. One teacher might have been juggling three kinds of needs at once: advanced students who were eager to move ahead, students with anxiety who needed a slower pace, and deaf students who required a different communication channel altogether. It was not easy to meet all those needs in a 45-minute period. Teachers often had to decide: did I slow down and support the few, or did I keep pace for the rest?

Looking ahead, professional development for math teachers was key. They needed tools to differentiate instruction, use visuals effectively, and design multimodal lessons. Co-teaching models, where the subject teacher and the support teacher planned and delivered lessons together, could have been a game-changer. When teachers shared responsibility, students benefited from richer instruction and more responsive support.

Peer-assisted learning also held promise. When students were encouraged to help one another, particularly during math problem solving, something shifted. Deaf students felt included. Hearing students grew more patient and collaborative. It created a stronger classroom community.

Investment in technology helped too. Interactive simulations, augmented reality tools, and hands-on manipulatives could have given students, especially those who relied on visual processing, a better way into difficult topics.

There was still work to do. But the pieces were in place: committed teachers, responsive leadership, and students who were open to learning together. With continued reflection, training, and creativity, inclusive math education could have moved from aspiration to daily reality.

CONCLUSION

Through close observation and interaction with the students and teachers in Class 12B, one thing became very clear: teaching mathematics to deaf students in an inclusive setting required far more than simply modifying the curriculum. It called for a mindset shift, a way of seeing each student not as someone to "catch up" but as someone with a different path to understanding.

In this class, strategies like visual learning, guided examples, and one-on-one support from teachers were not only "nice to have." They were essential. Respondent A and B, for instance, needed very different kinds of support. One responded well to structured materials and visual cues. The other needed content broken down into smaller steps, repeated and reinforced over time. What worked for one did not always work for the other and that was a reminder that inclusive education was rarely linear.

Communication turned out to be the thread that tied everything together. Whether through sign language, gestures, or even carefully written notes, making meaning accessible was

the foundation of every successful lesson. Support teachers, often overlooked in traditional teaching discussions, played a huge role here, not just in translating, but in re-teaching, encouraging, and walking alongside students who learned differently.

This study did not set out to find one perfect method, and it did not. But it did offer insight into what made inclusion feel real: flexibility, creativity, and the willingness to slow down when needed. The process was not always smooth, and some challenges, especially around abstract reasoning and limited expertise among support staff remained. But what worked now could be the base for what improved next.

Inclusive mathematics education, then, was not a fixed formula. It was responsive. And when schools gave teachers the room to adapt and listen closely to their students, deaf learners began to experience math not as a barrier, but as a subject they, too, could explore and enjoy.

RECOMMENDATIONS

Looking back at what worked in Class 12B, a few suggestions stand out that not as rigid solutions, but as ideas worth trying in similar settings.

1. Teachers, both subject specialists and support staff, need more time and space to learn how to teach inclusively. Training is important, yes, but so is ongoing practice. Workshops on using visual tools, designing step-by-step lessons, or even learning basic sign language could go a long way. Support teachers, especially, would benefit from extra training in math content. They already have the communication skills; now they need the tools to teach math more deeply.
2. Collaboration matters. When math teachers and support teachers work together, not just in the classroom, but in planning and reflecting, students benefit. Co-teaching, shared lesson design, and regular check-ins between staff can help create a more cohesive experience for deaf learners. It also gives both teachers a better understanding of what's working and what needs to be changed.
3. Schools should consider investing in better materials. Not fancy ones, necessarily, but ones that make math visible. Color-coded charts, interactive apps, simulations, even printed guides that walk through a concept slowly, these things help. For deaf students who rely on visual processing, they can be game-changers.
4. Don't forget the classmates. Structured peer support programs, even something as simple as teaching fingerspelling to hearing students, helps build connection. Deaf students do not only need academic access, they need community. And when their peers can communicate with them, even in small ways, the classroom becomes a more welcoming space.
5. There is more to explore. Future research could look deeper into how different teaching methods affect deaf students over time. What works best for conceptual math? How can technology help? What do students themselves say they need? These are questions worth answering and the answers will shape the future of inclusive classrooms.

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