



Differentiated Instruction Based on Deep Learning In Science Education for Grade XI MDVI Students

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ABSTRACT

This study examines the implementation of differentiated instruction based on Deep Learning within the Merdeka Curriculum in science instruction for Grade XI students with MDVI at a special senior secondary school, with the objectives of describing their learning capabilities, identifying the difficulties the teacher faces, analysing the efforts undertaken to overcome those difficulties, and examining how the differentiation is enacted. The study employed a descriptive qualitative case study within an interpretive paradigm. Data were collected through semi-structured interviews with the science teacher, non-participatory classroom observation, and documentary study of initial assessment records, the Individualised Education Programme, worksheets, and student portfolios, and were analysed using the interactive model of Miles, Huberman, and Saldaña; data validity was maintained through source and technique triangulation, prolonged observation, and thick description. The findings reveal sharply contrasting capability profiles: one student accesses material through Braille and tactile exploration, while the other relies on auditory-verbal processing. The teacher encounters five interrelated difficulties, namely concretising abstract concepts, linking material to students' interests, sustaining students' mood, serving differences in readiness simultaneously, and coping with limited adaptive media and distraction in a shared classroom, and responds through concrete media drawn from the immediate environment, an individualised approach grounded in initial assessment, the use of students' interests as an entry point, and the connection of material to real experience. Differentiation of content, process, and product is enacted systematically, while deep learning is realised through connection to everyday life and routine reflective evaluation.

INTRODUCTION

The global movement toward inclusive education has fundamentally reshaped how education systems respond to learner diversity. The United Nations Convention on the Rights of Persons with Disabilities (UNCRPD, 2006) affirms every child's right, including that of persons with disabilities, to inclusive, equitable, and quality education, while the contemporary global education agenda calls for a pedagogical reorientation responsive to learners' neurological and physical diversity (Ainscow, 2020; UNESCO, 2021). Within special education, access to science education is no longer regarded merely as the fulfilment of a formal right, but as a means of building cognitive independence and analytical reasoning (García-Holgado et al., 2021). Many countries have accordingly adopted inclusive education policies, yet translating those policy commitments into pedagogical practice remains a persistent challenge, particularly for students with low-incidence disabilities such as Multiple Disabilities with Visual Impairment (MDVI). Two pedagogical frameworks serve as the analytical lens for addressing this problem. Differentiated instruction (Tomlinson, 2014) adjusts content,



process, and product according to students' readiness, interests, and learning profiles through flexible learning pathways rather than separate lessons for each student. Deep learning, grounded in the principles of meaningful, reflective, and sustained learning, cultivates conceptual understanding, active engagement, and higher-order thinking skills (Fullan & Langworthy, 2014), especially when learning activities are closely connected to real experience (Nawawi, 2025). The convergence of the two holds strong potential for meeting the needs of learners with severe disabilities, yet empirical evidence on their integrated application in special education remains very limited.

Among the various populations of persons with disabilities, students with MDVI present the most complex educational challenges. MDVI refers to students who experience visual impairment combined with one or more additional disabilities, such as intellectual, physical, or communicative barriers, resulting in educational needs that cannot be met by programmes designed for a single disability category (Tsabita et al., 2026). In special schools, students with MDVI often struggle with fundamental skills such as spatial recognition and orientation, and therefore depend heavily on teachers' verbal guidance, because Braille-based markers are not always effective given students' limited proficiency and working memory in accessing them (Rijal et al., 2026). The scarcity of trained professionals and support systems further compounds these challenges (Supriyanto, 2020). In Indonesia, most special schools lack structured instructional strategies designed specifically for children with MDVI, and existing service models tend to emphasise self-care or activities of daily living over the mastery of academic concepts such as science (Sidik et al., 2024). In science education specifically, students with visual impairment still lack access to appropriate instructional media, which makes engagement with abstract concepts difficult and limits their opportunity to obtain equitable education (Mukhwana et al., 2025). The problem is aggravated by the tendency of the inclusive science teaching literature to presuppose that learners retain at least one intact sensory modality as a compensatory pathway (Maguvhe, 2015; Wild et al., 2018), an assumption that does not hold for students with MDVI. Recent research shows that multisensory and hands-on teaching strategies can improve conceptual understanding among students with visual impairment (Yektyastuti et al., 2026), yet the translation of these strategies into a differentiated and systematic pedagogical framework remains underdeveloped.

Normatively, differentiated instruction is proactive and rooted in continuous assessment that consistently informs instructional decisions (Tomlinson, 2014); the deep learning paradigm within the Merdeka Curriculum emphasises meaningful learning that connects abstract concepts to students' real experiences through reflective and enjoyable engagement (Kemendikbudristek, 2022); and the principles of Universal Design for Learning advocate multiple means of engagement, representation, and expression so that all students can access the curriculum (CAST, 2018). Classroom practice presents a different picture. Teachers report difficulty providing adequate instructional media, adapting abstract concepts, and managing the wide range of abilities in heterogeneous classes (Yunaini et al., 2024), while science teaching in special schools still relies on partial repetition and intuitive simplification of instruction without structured differentiation planning. Infrastructural limitations, including shared or multigrade classrooms and learning environments that generate distraction, further complicate the situation (Sidik et al., 2024). It is this gap between policy aspiration and classroom reality that calls for empirical research on how differentiated instruction based on deep learning can be operationalised for students with MDVI in science education.

Three interlocking gaps emerge from this synthesis. Contextually, there is insufficient empirical research on differentiated instruction for students with MDVI in Indonesian special senior secondary schools, as existing studies centre on inclusive primary schools or single-category disabilities. Integratively, the theoretical compatibility between differentiated instruction and deep learning, both of which emphasise responsiveness to diversity and meaningful engagement, has not been empirically

tested with students with complex disabilities. Pedagogically, the challenges of concretising abstract concepts, adapting media, managing heterogeneous abilities, and creating meaningful learning experiences for students with MDVI have not been systematically documented through the lens of these two frameworks, and systematic reviews of differentiated instruction in science education still record a gap concerning students' emotional and motivational needs (Herliana et al., 2024), a dimension that is decisive for the MDVI population. Without structured differentiation, students with MDVI risk academic marginalisation and the loss of opportunities to develop functional scientific understanding.

Prior research has advanced along three lines that have yet to converge. On the first, Bondie et al. (2019) show that the shift from uniform to differentiated teaching substantially changes how teachers design tasks and manage heterogeneous classes, and research in special schools reveals systematic adjustments to content, process, product, and learning environment: process differentiation for students with hearing impairment through sign language, lip reading, and hands-on activities alongside product grouping by readiness (Engko et al., 2026), stages from needs identification through continuous evaluation for students with autism spectrum disorder that improved social skills and academic engagement (Lisdiana et al., 2025), and modification of material complexity, concrete media, and assessment formats for students with intellectual disabilities (Yunaini et al., 2024); their success depends heavily on teacher readiness, continuous assessment, and institutional support. On the second, deep learning has been shown to strengthen conceptual understanding and higher-order thinking skills in science learning under the Merdeka Curriculum (Nawawi, 2025), and the stages of stimulus, exploration, discussion, and reflection foster students' cognitive, emotional, and social engagement (Sari, 2022); yet such studies remain concentrated on general education populations, so how these approaches may be adapted for students with complex disabilities is not well understood. On the third, research on science education for students with visual impairment confirms historical exclusion arising from the visual nature of science materials and the scarcity of appropriate media (Mukhwana et al., 2025), while multisensory, hands-on, and assistive technology strategies promise improved conceptual understanding even though their integration as pedagogical tools remains limited (Yektyastuti et al., 2026). For students with MDVI, the combination of visual impairment with additional disabilities complicates strategy selection, whereas available instructional design models are directed more toward self-care skills than academic conceptual mastery (Sidik et al., 2024); differentiation for students with visual impairment has moreover been explored only in mathematics, not in science teaching grounded in deep learning.

The novelty of this study lies in formulating an integrated framework that unites Tomlinson's (2014) differentiated instruction model with the deep learning approach of the Merdeka Curriculum, and then applying it specifically to students with MDVI in Grade XI of an Indonesian special school, a population and educational level that have received insufficient academic attention. Unlike prior research that situates both frameworks within general education populations or single-category disabilities, this study documents how the two operate in a resource-constrained special education setting through a qualitative case study design linking teacher perspectives, classroom observation, and documentary evidence, thereby producing a map of adaptation strategies comprising locally sourced multisensory media modification and verbal-tactile assessment adjustment amid facility constraints and physical classroom distraction.

Proceeding from these gaps and this novelty, the study aims to describe the learning capabilities of students with MDVI in following science instruction in Grade XI of a special senior secondary school, to identify the difficulties teachers face in delivering it, to analyse teachers' efforts to overcome the barriers that arise, and to examine the implementation of differentiated instruction based on deep learning in science education for students with MDVI. Accordingly, this study is

expected to extend differentiated instruction theory to the MDVI population and to test the relevance of the deep learning framework within special education pedagogy, to provide evidence-based guidance for teachers in designing meaningful and differentiated science instruction, and to inform policy on the provision of facilities, adaptive media, and the science curriculum at the special senior secondary level.

METHODS

This study employed a descriptive qualitative case study design with a naturalistic interpretivist approach to analyse the implementation of differentiated instruction based on deep learning in science education for students with MDVI at a special senior secondary school. The case study design was selected because it is appropriate for exploring contemporary phenomena in real-life contexts where the boundary between the phenomenon and its environment is not clear-cut (Merriam, 2009; Yin, 2018), a condition that characterises this study because the teacher's differentiation practice cannot be separated from the shared classroom, the scarcity of media, and the environmental distraction surrounding it. The interpretivist approach directed the researcher toward how the teacher makes sense of her instructional practice, perceives the challenges she faces, and constructs strategies to address them (Creswell & Poth, 2018; Merriam & Tisdell, 2016). The study was conducted at SLB A P, a special school for learners with visual impairment in Bandung, West Java, purposively selected because it provides services for students with MDVI at the senior secondary level, operates under the Merdeka Curriculum, and exhibited significant science learning challenges during preliminary observation. The Grade XI classroom is shared with Grade XII students owing to limited space and teaching personnel, while the same room also functions as a Braille printing unit and computer laboratory, generating auditory distraction that affects students' focus and emotional stability. These conditions reflect the reality of many Indonesian special schools, thereby enhancing the potential transferability of the findings to comparable contexts (Lincoln & Guba, 1985).

Participants were selected purposively to obtain informants with direct experience of teaching students with MDVI (Creswell & Poth, 2018; Merriam, 2009). The central informant was the science teacher responsible for Grade XI students with MDVI at SLB A P, with at least one year of experience teaching students with MDVI, because the teacher is the key actor in implementing differentiated instruction as well as the holder of insight into students' capabilities, instructional challenges, and the strategies pursued. As supporting data sources, the study explored the learning activities of two Grade XI students with MDVI, Student W and Student Z, whose capability profiles are sharply contrasting. Additional data sources comprised classroom observation field notes recording teaching and learning activities, teacher-student interaction, and the use of instructional media, together with planning and assessment documents including initial assessment results, the Individualised Education Programme, modified worksheets, and portfolios of student work as evidence of differentiation practice. This diversity of sources enabled triangulation, which enhances the credibility of findings through the corroboration of evidence from different sources and methods (Lincoln & Guba, 1985).

Data were collected through in-depth interviews, non-participant observation, and documentary study, which complement one another in capturing both the explicit and the tacit dimensions of instructional practice along with the contextual factors shaping it (Merriam & Tisdell, 2016). Interviews were conducted with the science teacher across four sessions guided by a semi-structured protocol developed from the research objectives and preliminary observation, comprising open-ended questions on the teacher's perceptions of students' learning capabilities, the difficulties encountered, the strategies pursued, and the implementation of differentiated instruction within the deep learning framework; each session lasted 60 to 90 minutes on the school premises, was recorded

with the participant's consent, and was transcribed verbatim. Classroom observation was carried out across several lessons on different topics, with the researcher acting as a non-participant observer to minimise disruption while systematically recording teaching methods, the use of instructional media, patterns of student engagement, teacher-student interaction, and classroom environmental conditions, thereby surfacing behavioural and contextual information that participants might not articulate (Yin, 2018). The documentary study examined initial assessment results, the Individualised Education Programme, student worksheets and assessment records, and portfolios of student work, which reveal how content, process, and product were designed and differentiated for the two students, while also serving as a non-reactive data source that strengthens the credibility of the data corpus (Creswell & Poth, 2018).

Data were analysed using the interactive model of Miles, Huberman, and Saldaña (2014), which proceeds concurrently and iteratively through data condensation, data display, and the drawing and verification of conclusions. Condensation involved selecting, focusing, and simplifying raw data from interviews, observation, and documents: transcripts were read repeatedly, then coded inductively while preserving the participant's language and deductively by deriving codes from the frameworks of differentiated instruction (Tomlinson, 2014) and deep learning (Fullan & Langworthy, 2014). These codes were grouped into the categories of initial assessment, content differentiation, process differentiation, product differentiation, connection to real experience, and environmental barriers, and were then synthesised into themes addressing the four research objectives. Data display involved juxtaposing themes across sources, namely the teacher's perspective from interviews, classroom observation notes, and documentary evidence, so that patterns and variations could be identified, while conclusion drawing proceeded iteratively by moving back and forth between the data and the emerging interpretation until data saturation was reached.

The trustworthiness of the data was maintained through the criteria of Lincoln and Guba (1985). Credibility was strengthened through source and method triangulation by drawing data from interviews, observation, and documents, together with prolonged engagement across repeated observation and interview sessions, while transferability was addressed through thick description of the school setting, classroom conditions, student characteristics, and instructional dynamics. Dependability and confirmability were supported by the inclusion of direct participant quotations in the reporting of findings so that the connection between data and interpretation can be traced. Ethically, the researcher obtained official permission from the school principal and informed consent from the participating teacher regarding the purpose, procedures, and right to withdraw (Creswell & Poth, 2018). Because students with MDVI constitute a vulnerable population and were not interviewed directly, consent for observation was processed through coordination with the school and written consent from parents or guardians, accompanied by the principle of assent whereby observation was discontinued if a student showed refusal or discomfort. Confidentiality was ensured through the pseudonyms SLB A P, Student W, and Student Z, and through the secure storage of all recordings, transcripts, and documents on a device accessible only to the researcher.

RESULTS AND DISCUSSION

Learning Capabilities of Students with MDVI in Following Science Instruction

Interviews, classroom observation, and documentary study show that the capabilities of Grade XI students with MDVI in following science instruction vary widely across academic, sensory, and learning-style dimensions. Initial assessment revealed that Student W can still read and write Braille and understands simple concepts more readily, though requiring more time to process information, whereas Student Z demonstrates more active verbal skills but is severely limited in reading and writing Braille. The teacher underscored the instructional consequence of this contrast: “I have to adjust the

way I teach for each child” (G1). Neither student is yet able to grasp science content fully in line with the Grade XI Learning Outcomes, so the teacher simplifies the material into core concepts. Observation corroborated this account: students followed lessons more successfully when content was delivered through concrete objects and direct experience, such as palpating their own bones while studying the human skeleton, and when the learning atmosphere was relaxed and enjoyable. Their participation likewise increased when the teacher connected the respiratory system material to singing, an activity they enjoy, compared with material delivered orally without variation. A summary of both students' capability profiles is presented in Table 1.

Table 1. Learning Capability Profiles of Grade XI Students with MDVI

Capability Aspect	Student W	Student Z	Capability Aspect
Braille reading ability	Able to read basic-level Braille	Still limited; requires assistance	Braille reading ability
Braille writing ability	Able to write simple Braille	Very limited; uses assistive tools	Braille writing ability
Verbal ability	Reasonably active, but prefers listening	Highly active and communicative orally	Verbal ability
Understanding of science concepts	Able to grasp simple concepts with concrete objects	Understands through oral repetition and memorisation	Understanding of science concepts
Dominant learning style	Visual-tactile, through Braille and concrete objects	Auditory-verbal, through oral explanation and memorisation	Dominant learning style
Level of learning independence	Reasonably independent with minimal assistance	Requires intensive assistance	Level of learning independence
Learning interest	Enjoys activities involving real objects	Enjoys singing and storytelling	Learning interest
Capability Aspect	Student W	Student Z	Capability Aspect

This diversity confirms that the characteristics of students with multiple disabilities cannot be accommodated by conventional, uniform instructional models. The finding aligns with Tsabita et al. (2026), who state that the educational needs of students with MDVI cannot be met by programmes designed for a single disability category because they experience visual impairment in combination with additional barriers. Consequently, adjustment of content levels must follow each student's cognitive capacity and learning needs rather than merely satisfying administrative curricular targets, as Hakim (2022) emphasises that learners with visual impairment and additional barriers require individualised material and strategy adaptation. In this study, Student W required strengthening of academic skills through Braille and concrete objects, whereas Student Z required an auditory-verbal approach drawing on her capacity to listen and memorise.

The increase in participation when the learning atmosphere was relaxed and enjoyable indicates that emotional readiness substantially influences learning success, consistent with the deep learning principle emphasising enjoyable and reflective learning (Kemendikbudristek, 2022). Students with MDVI who face severe sensory and cognitive challenges require an environment that is not only physically safe but also psychologically comfortable (Sari, 2022), and they depend heavily on verbal guidance and a supportive atmosphere to access learning optimally (Rijal et al., 2026). Meanwhile, the contrast between Student W, who accesses material through Braille and concrete objects, and Student Z, who responds to an auditory-verbal approach, confirms the importance of identifying learning profiles as the first step in differentiation (Tomlinson, 2014). For the MDVI population this step becomes all the more critical because limitations may affect more than one sensory modality, requiring teachers to identify the most effective learning pathway for each individual. This condition also exposes the limitation of the assumption prevailing in the inclusive science teaching literature, which presupposes the availability of one intact compensatory modality (Maguvhe, 2015; Wild et al.,

2018). The learning capability of students with MDVI is therefore not a homogeneous entity but a spectrum demanding flexible pedagogical responses, making comprehensive initial assessment covering academic, sensory, learning-style, and interest dimensions a non-negotiable foundation.

Teachers' Difficulties in Science Instruction for Students with MDVI

The teacher encounters a number of difficulties in delivering science instruction to students with MDVI. Interviews and observation identified five interrelated difficulties: simplifying complex and abstract science content, connecting material to students' interests, sustaining students' mood so that it remains conducive, serving the significant differences in capability between the two students in one classroom, and contending with limited instructional media as well as distraction in the learning environment. On the fourth difficulty, the teacher acknowledged that her attention becomes divided so that provision for one of the students is sometimes not optimal (G2). Limited media constitutes a distinct challenge: when conveying abstract concepts such as the skeleton, bones, the respiratory system, and human organs, the teacher has no access to adequate models or teaching aids, and could only ask students to feel their own chests while breathing, an approach she considered still insufficient. Fluctuations in students' mood likewise require the teacher to read their emotional condition and secure their comfort before lessons begin, absorbing additional time and energy. Observation recorded that the teacher frequently repeats explanations with varied approaches to ensure both students understand the material, while the classroom, which also functions as a Braille printing room and computer laboratory, generates auditory distraction that disrupts concentration, particularly for Student Z, who relies heavily on hearing.

The difficulty of conveying abstract concepts indicates that science instruction for students with MDVI demands not only mastery of content but also a high capacity for pedagogical adaptation and modification. This finding aligns with Mukhwana et al. (2025), who observe that students with visual impairment have historically faced exclusion from science education because of the visual nature of scientific concepts and materials, so abstract concepts must be made concrete through direct experience rather than through visual representation or text that cannot be accessed. Yektyastuti et al. (2026) found that multisensory and hands-on strategies improve the conceptual understanding of students with visual impairment, yet their implementation is often hampered by limited media and resources, while Wulandari (2021) maintains that instruction for students with multiple disabilities becomes effective only when supported by concrete objects and real experience. Lacking access to specialised teaching aids such as palpable organ models, the teacher in this study relied on creativity by drawing on students' own bodies and objects at hand, making teachers' pedagogical competence the principal determinant of instructional success amid constrained facilities.

The difficulty of sustaining students' mood is an important finding that is often overlooked in the literature on science education for students with disabilities. Herliana et al. (2024) identify a gap in addressing students' emotional and motivational needs in differentiated science learning, and this study confirms that emotional factors are central for students with MDVI, who are prone to sensory fatigue, frustration, or mood changes, requiring teachers to read and respond to emotional conditions in the moment.

The difficulty of serving differences in capability within a single classroom underscores the importance of systematic differentiation. Yunaini et al. (2024) show that differentiated science learning for students with intellectual disabilities requires teachers to modify material complexity, use concrete media, and adjust assessment formats according to individual readiness. In the MDVI context this challenge is more complex because the differences are not only cognitive but also concern the sensory modalities available: Student W, who can still access Braille, follows a learning pathway different from that of Student Z, who relies on hearing, so the teacher must differentiate not only content but also media and delivery strategies fundamentally.

Limited media simultaneously reveals the importance of adequate facility support for teachers. When formal media at school are scarce, the burden of curricular adaptation rests entirely on the teacher, creating an unsustainable situation with the potential to induce teacher burnout. This condition supports Supriyanto (2020), who highlights the scarcity of trained professionals and support systems for children with MDVI in Indonesia, and indicates that teachers' pedagogical competence is measured by the capacity to devise strategies aligning content and process with students' interests and characteristics rather than by content mastery alone.

Teachers' Efforts to Overcome Difficulties in Science Instruction

The teacher pursued a series of adaptive, learner-centred strategies to overcome these difficulties: creating an enjoyable learning atmosphere by integrating topics students like, drawing on readily available concrete media, applying an individualised approach based on initial assessment results, and connecting material to students' real experience. Because Student Z enjoys singing, the teacher composed a simple song about inhaling and exhaling to explain the respiratory system, while Student W received a simple Braille text carrying the same song, and this approach increased the attention and participation of both. In terms of media, the teacher drew on students' own bodies, objects in the surrounding environment, media available at school, and media she made herself: students were asked to palpate their ribs, finger bones, and joints while studying the human skeleton, and the teacher brought leaves to explain the parts of a plant. The individualised approach followed initial assessment, with Student W focused on Braille reading and writing while Student Z received oral explanation, repetition, memorisation, and comprehension checks through oral questioning. Material was also linked to daily life through questions about the food students had eaten and the presentation of real fruit to be felt and smelled, because in the teacher's view students' understanding improves when the material relates directly to themselves (G3). Observation further recorded the repetition of material with varied approaches: after a concept had been explained through concrete objects, students were asked to restate it in their own words, then reinforcement followed through practical activities or simple games, and the cycle was repeated until the teacher was satisfied that the basic concept had been understood. A summary of the teacher's efforts is presented in Table 2.

Table 2. Teachers' Efforts to Overcome Difficulties in Science Instruction

Difficulty Encountered	Teacher's Effort	Example of Implementation
Abstract science concepts	Use of concrete media; connection to real experience; simplification of material	Using body parts to explain the skeleton and joints; bringing objects from the surrounding environment to explain plant parts
Differences in capability between students	Individualised approach based on initial assessment; differentiation of content, process, and product	Student W assigned Braille reading and writing tasks; Student Z given oral explanation and memorisation
Fluctuating student mood	Creating an enjoyable learning atmosphere; integrating student interests	Using songs and games; adjusting the pace of instruction to students' condition
Limited instructional media	Using media available nearby; making simple media independently	Using real fruit, leaves, and stems; making simple teaching aids from cardboard and recycled objects
Distraction in the learning environment	Managing time and seating; creating a quieter learning zone	Moving students' seats away from the source of distraction; giving clearer and firmer instructions

These strategies demonstrate a reasonably sound application of differentiation principles amid the constraints at hand. The individualised approach grounded in initial assessment enabled the teacher to focus on strengthening Braille-based academic skills for Student W and an auditory-verbal approach for Student Z, consistent with Tomlinson's (2014) principle of process differentiation,

which holds that teachers must adjust how students access and process information according to their respective learning profiles.

The use of concrete media drawn from objects in the surrounding environment and from students' own bodies reflects learner-centred instruction and supports Yektyastuti et al. (2026), who show that multisensory and hands-on strategies improve the conceptual understanding of students with visual impairment in science. Through touching, handling, and experiencing directly, students with MDVI construct stronger mental representations of abstract concepts than could be achieved through verbal explanation alone.

The integration of student interests reflects differentiation that is responsive to interest, as Tomlinson (2014) emphasises that connecting content to students' interests heightens motivation and emotional engagement. For students with MDVI, who are limited in accessing conventional learning resources, interest becomes an effective entry point to learning; the use of song is not only enjoyable but also aids the recall of information through melody and rhythm, while drawing on Student Z's auditory memory strengths.

Connecting material to students' real experience reflects the deep learning principle emphasising active engagement, the relevance of learning experience, and the construction of meaning (Nawawi, 2025). By linking science concepts to the food students eat daily or to their own bodies, the teacher helped them build connections between new knowledge and prior experience, thereby improving retention and understanding. Repetition with varied approaches, from concrete objects to verbal explanation and from practical activities to games, accords with the needs of students with MDVI, who require more time to process information and consolidate understanding (Tsabita et al., 2026), because repetition across formats strengthens memory traces. These findings indicate that teachers' creativity and dedication can overcome most facility constraints, consistent with Rahman and Putri (2023), who state that teachers in special schools require competence extending beyond content mastery to include the capacity to adapt rapidly to students' diverse and changing needs.

Implementation of Differentiated Instruction Based on Deep Learning

The implementation of differentiated instruction based on deep learning in the Grade XI MDVI classroom began with initial assessment to establish each student's capabilities and needs, which formed the basis for adjusting content, process, and product flexibly, with continuous evaluation throughout instruction. In the content dimension, the teacher simplified Grade XI science material into core concepts closest to students' lives: the respiratory system was reduced to the functions of the nose, throat, and lungs connected to everyday breathing, while healthy food was presented as a distinction between food that is good and not good for the body without elaborating carbohydrates, proteins, and fats, and was delivered through simple stories, songs, and tactile activities rather than lengthy text or visual diagrams. In the process dimension, Student W was engaged in reading Braille, writing simple words, and expressing opinions orally, whereas Student Z was directed toward listening to explanations, memorising through oral repetition, and answering oral questions, with a longer time allocation and more intensive guidance for Student Z. In the product dimension, Student W received simple written tasks such as writing the names of body organs in Braille using a slate and stylus or completing modified worksheets, whereas Student Z was assessed through oral questioning and recitation such as naming the function of the nose or indicating the body part referred to. Deep learning elements were evident in the connection of material to students' real lives, the use of concrete objects such as leaves and flowers from the school garden that students felt and smelled, and reflective activities in the form of simple questions about what had been learned and how their breathing moved. The teacher summarised this orientation by stating, "They remember

better because they experience it directly” (G4). A matrix of differentiation implementation for both students is presented in Table 3.

Table 3. Matrix of Differentiated Instruction Implementation Based on Deep Learning

Dimension	General Application	Difference Between Student W and Student Z	Deep Learning Support
Content differentiation	Simplification of material; selection of functional core concepts	W: simple Braille text with basic vocabulary. Z: oral explanation with repetition and reduced scientific terminology	Content connected to students' real experience, such as everyday food and their own bodies
Process differentiation	Adjustment of learning activities; individualised approach	W: reading Braille, writing, expressing opinions. Z: listening, memorising through song and repetition, answering orally	Activities involve direct experience, concrete objects, and an enjoyable learning atmosphere
Product differentiation	Adjustment of task and assessment format	W: simple written tasks using slate and stylus. Z: oral assessment through questioning and recitation	Products take the form of experiential reflection; assessment uses reflective questions
Instructional media	Use of concrete and adaptive media	W: Braille and modified worksheets. Z: concrete objects and tactile teaching aids. Both: body parts and nearby objects	Media enable multisensory experience through touch, smell, and hearing
Connection to real life	Material linked to students' everyday experience	W: writing about eating experiences. Z: recounting daily activities related to science	Building meaning and relevance; encouraging reflection on experience

Discussion

The contrasting capability profiles found in this study qualify an assumption that runs through much of the inclusive science teaching literature, namely that learners retain at least one intact sensory modality that can serve as a compensatory pathway (Maguvhe, 2015; Wild et al., 2018). For students with MDVI the compensatory pathway is itself partial and student-specific: Student W's access ran through Braille and tactile exploration, whereas Student Z's ran through auditory-verbal processing, so that the same concept had to be entered from two different sensory directions. This corroborates Tsabita et al. (2026), who characterise MDVI as a configuration of needs that cannot be met by programmes designed for a single disability category, and it explains why Rijal et al. (2026) find Braille-based markers unreliable where students' proficiency and working memory are limited. Read through Tomlinson's (2014) construct of the learning profile, the finding indicates that for this population the profile is not one differentiation variable among three but the precondition for the other two.

The five difficulties reported by the teacher align with the pattern documented in recent studies of differentiation in special schools, where success depends less on teachers' willingness than on teacher readiness, continuous assessment, and institutional support (Bondie et al., 2019; Yunaini et al., 2024). Two of the five, however, extend that pattern. The difficulty of sustaining students' mood gives empirical form to the emotional and motivational gap that Herliana et al. (2024) identify in systematic reviews of differentiated science instruction, and it appears here as a condition of access rather than a peripheral concern. The difficulty of limited adaptive media and classroom distraction reproduces the structural scarcity reported by Mukhwana et al. (2025) and Sidik et al. (2024); yet the teacher's response of substituting body parts and objects from the immediate environment for unavailable commercial teaching aids shows that the multisensory strategies known to improve conceptual understanding among students with visual impairment (Yektyastuti et al., 2026) can be improvised from local resources when procurement fails. The use of student interest, such as singing,

as an entry point similarly operationalises the engagement dimension of Universal Design for Learning (CAST, 2018) under resource constraints.

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The contrasting capability profiles found in this study qualify an assumption that runs through much of the inclusive science teaching literature, namely that learners retain at least one intact sensory modality that can serve as a compensatory pathway (Maguvhe, 2015; Wild et al., 2018). For students with MDVI the compensatory pathway is itself partial and student-specific: Student W's access ran through Braille and tactile exploration, whereas Student Z's ran through auditory-verbal processing, so that the same concept had to be entered from two different sensory directions. This corroborates Tsabita et al. (2026), who characterise MDVI as a configuration of needs that cannot be met by programmes designed for a single disability category, and it explains why Rijal et al. (2026) find Braille-based markers unreliable where students' proficiency and working memory are limited. Read through Tomlinson's (2014) construct of the learning profile, the finding indicates that for this population the profile is not one differentiation variable among three but the precondition for the other two.

The five difficulties reported by the teacher align with the pattern documented in recent studies of differentiation in special schools, where success depends less on teachers' willingness than on teacher readiness, continuous assessment, and institutional support (Bondie et al., 2019; Yunaini et al., 2024). Two of the five, however, extend that pattern. The difficulty of sustaining students' mood gives empirical form to the emotional and motivational gap that Herliana et al. (2024) identify in systematic reviews of differentiated science instruction, and it appears here as a condition of access rather than a peripheral concern. The difficulty of limited adaptive media and classroom distraction reproduces the structural scarcity reported by Mukhwana et al. (2025) and Sidik et al. (2024); yet the teacher's response of substituting body parts and objects from the immediate environment for unavailable commercial teaching aids shows that the multisensory strategies known to improve conceptual understanding among students with visual impairment (Yektyastuti et al., 2026) can be improvised from local resources when procurement fails. The use of student interest, such as singing, as an entry point similarly operationalises the engagement dimension of Universal Design for Learning (CAST, 2018) under resource constraints.

This pattern of implementation reflects systematic differentiation, with initial assessment as the basis for mapping students' capabilities and needs and as the reference for modifying material, methods, media, and assessment forms, consistent with Tomlinson's (2014) framework holding that effective differentiation begins with a thorough understanding of students' readiness, interests, and learning profiles. Simplifying Grade XI material into core concepts does not mean lowering standards but rather accessing the essence of the content through pathways better suited to students' cognitive and sensory capacities, as Engko et al. (2026) demonstrate that content differentiation in special schools proceeds by selecting key concepts and presenting them in accessible formats. Selecting functional material with direct relevance to students' lives helps them perceive the meaning and usefulness of what they learn (Yunaini et al., 2024).

In the process dimension, engaging Student W through reading, writing, and expressing opinions draws on her visuo-tactile strengths via Braille, whereas directing Student Z toward listening, memorising, and responding orally draws on her auditory-verbal strengths. This pattern reflects the principle of providing access to content through the pathway most effective for each student (Tomlinson, 2014) as well as the principles of Universal Design for Learning, which supply multiple means of representation, expression, and engagement (CAST, 2018).

In the product dimension, assigning simple written tasks to Student W and oral assessment to Student Z reflects an understanding that assessment must measure comprehension through the format best suited to students' capabilities, thereby sparing them systemic failure arising from an

inability to use standard test instruments. Lisdiana et al. (2025) found that adjusting final products and assessment formats is essential for demonstrating students' understanding fairly and accurately, while also building their confidence.

Deep learning elements, particularly the connection of material to everyday experience and the use of concrete objects, reveal an effort to build meaningful understanding through active engagement and experience-based construction of meaning (Nawawi, 2025). Although some students still rely on memorisation, the use of concrete objects and routine reflective assessment shifted the learning orientation from mere memorisation toward the construction of meaning, a shift that matters because the limited working memory and information-processing capacity of students with MDVI demand direct experience and varied repetition (Rijal et al., 2026).

Theoretically, these findings indicate that Tomlinson's (2014) differentiated instruction framework and the principles of deep learning (Fullan & Langworthy, 2014; Kemendikbudristek, 2022) are relevant for students with complex disabilities such as MDVI, with the caveat that implementation must account for the sensory and cognitive characteristics unique to this population. That relevance does not stand alone, because institutional barriers in the form of limited media, environmental distraction, and shared classroom conditions continue to constrain teachers' room for manoeuvre. The contribution of this study to the inclusive science education literature therefore lies in showing that adaptive and meaningful instruction can still enhance the engagement and understanding of students with MDVI, though its attainment depends on institutional support that has thus far been inadequate.

Taken as a whole, the academic contribution of this study is threefold. Empirically, it documents differentiated science instruction for students with MDVI at the special senior secondary level, a population and educational stage largely absent from a literature concentrated on inclusive primary schools and single-category disabilities. Theoretically, it extends Tomlinson's (2014) differentiation model and the deep learning framework of the Merdeka Curriculum (Fullan & Langworthy, 2014; Kemendikbudristek, 2022) beyond general education populations and shows the two to be mutually reinforcing rather than parallel, provided that the learning profile is treated as the entry point of differentiation rather than one variable among several. Practically, it offers a transferable map of adaptation strategies, comprising verbal-tactile assessment adjustment, locally sourced multisensory media, and interest-based entry points, for teachers working without adequate adaptive facilities.

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CONCLUSION

This study set out to describe the science learning capabilities of Grade XI students with MDVI, to identify the difficulties their teacher faces, to analyse the efforts undertaken to overcome those difficulties, and to examine how differentiated instruction based on deep learning is enacted.

Across the four objectives the evidence converges on a single proposition: meaningful science learning for this population is governed less by the severity of the disability than by the precision with which instruction is matched to the sensory pathway each student actually uses. Contrasting capability profiles required not two variants of one lesson but two distinct routes to the same core concepts; the barriers that emerged were pedagogical and institutional rather than a reflection of students' incapacity; and the responses that worked, namely assessment-driven individualisation, concrete media drawn from the immediate environment, and interest as an entry point, all rest on re-mediating abstract content through available senses. Differentiation of content, process, and product thus functioned as the operational vehicle through which deep learning was realised, indicating that the two frameworks are mutually reinforcing rather than parallel and that their integration constitutes a viable pedagogical route for learners with complex disabilities.

This study is bounded by a single special school setting with two students and one participating teacher, so its findings are contextual and interpretive rather than statistically generalisable, and the absence of longitudinal data means the durability of the observed gains cannot be established. Further research should therefore widen participant coverage across schools and regions and adopt a longitudinal design to test the long-term effect of differentiated instruction based on deep learning on the learning outcomes of students with MDVI. For practice and policy, the findings recommend the development of more varied multisensory media accessible to students with MDVI, the strengthening of teacher capacity through continuing professional development in designing differentiated instruction, and the provision of distraction-free learning spaces as part of an inclusive education policy that attends explicitly to low-incidence disabilities.

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