SPECIJALNA EDUKACIJA I REHABILITACIJA
2023, Vol. 22, Br. 3, str. 201-220
UDK: 37.091.3::5/6(594)
159.953.5-056.263-053.2(594)
Originalan naučni rad
DOI: https://doi.org/10.5937/specedreh22-41397

Science education practices for deaf and hard-of-hearing students in Indonesia

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Introduction. Traditionally, the curriculum for deaf learners mainly involved language acquisition at the expense of other academic subjects. Currently, their subjects also include other disciplines, like science, to enrich students' knowledge related to human life. *Objective*. This study aims to describe the implementation of school science practices and identifies the challenges in improving science education in special schools for deaf and hard-of-hearing (DHH) students as a guide for improving inclusive education of these students. *Methods.* The sample included four principals and six classroom science teachers from five DHH schools, using purposive sampling in the five schools that provide education for DHH students in three regencies of Regional V Banyumas, Central Java, Indonesia. Data were gathered through interviews, field observations, and artifacts. *Results*. The teachers use various teaching strategies and rely on visual and hands-on activities for DHH students. The schools provide sign language interpreters and speech-development programs as support for teachers and DHH students. All teachers need professional development in teaching collaboration opportunities to develop their expertise in teaching DHH students. The policy implementation, instructional strategies, resources, and teacher qualifications were found to be extrinsic factors. *Conclusion*. The teachers need support from the government to include them in relevant training programs and prepare teachers with special or inclusive education knowledge by adding courses in university-level education for all prospective teachers. The results are insightful for DHH students, science educators, and policymakers.

Keywords: Deaf and Hard-of-Hearing students, education practices, inclusive education, science education

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Introduction

The international community has assessed the progress of and challenges facing the attainment of the Education for All (EFA) and Sustainable Development Goal 4 (SDG 4) to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all by 2030. The educational sector has started to develop and implement effective strategies toward achieving SDG 4. Analyzing issues and challenges in global education, such as in science education, 'Science for all' should involve concepts and approaches that contribute to the various dimensions of science education that meet the needs and limitations of students' conditions (UNESCO, 2015).

This study is a direct response to students' decreasing motivation and interest in science learning. Many students consider science to be complicated because it contains abstract and theoretical knowledge (Buabeng & Ntow, 2010). Some studies have shown that the subject of science has traditionally been neglected in the curriculum for deaf learners (McIntosh et al., 1994; Molander et al., 2001; Moores & Martin, 2006). Until recently, the curriculum prioritized language acquisition at the expense of other academic subjects limiting students' learning in other fields, including scientific literacy (Khoo & Kang, 2022). Science education should be accessible to all learners, including children with special needs, to promote inclusive science practices (Atika et al., 2018). As a field of study that examines nature, science is strongly related to human life. Thus, every person must understand science or at least have basic scientific literacy.

Scientific literacy is necessary for everyone as it enables people to use scientific information to make everyday life choices (Yakwal & Keswet, 2018). However, the mastery of scientific literacy by students is still minimal. This can be shown based on the results of students' scientific literacy achievement in PISA (Program for International Student Assessment). Indonesia is included in a low level, specifically the bottom 10 positions, when scientific literacy is a very important factor in determining the quality of education in a country (OECD, 2014). Basic scientific literacy has been applied by some people in their daily lives to help their life activities, such as cooking using coal. Mastery of scientific literacy can also be correlated with the ability to understand scientific concepts. If someone understands the concepts of science that he has learned, then that person will also be able to apply science in everyday life (Supena et al., 2021). In addition, mastery of scientific literacy is also correlated with critical thinking skills. This is because someone who has good scientific literacy skills will be more critical and selective in filtering and solving the problems they face (Braund, 2021). Thus, science and its applications have an important role in solving problems in everyday life.

Scientific literacy consists of three aspects: scientific knowledge or concepts, scientific processes, and situation or context that needs to be instilled in every student so that they can be embedded in the ability to model logic and science in solving problems. Therefore, to ensure that students achieve a minimum level of science literacy, science is one of the main subjects in both general and special education from elementary school to junior high school (You et al., 2021). This is consistent with the results of previous observational studies in two Indonesian special schools, which showed that schools only focused on curriculum learning materials. Therefore, students, especially those with special needs, such as students who are deaf and hard of hearing (DHH), consider science boring and uninteresting (Donnellan & Mathews, 2021).

In addition, based on observation of deaf and hard-of-hearing (DHH) students learning in science classrooms, it appears that language and communication skills development takes priority in the learning process. DHH students sometimes have trouble with learning science, especially when it comes to understanding scientific terminology, because science learning is not thoroughly taught to DHH students. To help students develop better learning habits, critical thinking to construct understanding, and a greater grasp of scientific literacy, teachers must provide more explanations, relevant examples, and science instructions that emphasize meaningful learning (Yore, 2000). This needs to be instilled and strengthened in students who have special needs. Every student, especially those with special needs, must be able to solve every problem they face with scientific concepts to be able to think rationally (Majeed et al., 2021).

Special steps are needed to instill scientific literacy in students who have special needs. This is because students with special needs take longer to understand the instructions given by each teacher or instructor (Steed & Leech, 2021). Given the importance of the treatment given to students with special needs to strengthen scientific literacy, this study aims to explore the science education practices of DHH Indonesia schools to answer the needs of students related to inclusive science education and to find out the challenges faced by DHH students and educators in science learning. Specifically, this study answers the following questions (1) How is science learning integrated into the classroom for DHH students? (2) How do special schools provide science education for DHH students? (3) What strategies are applied by principals and teachers to improve science education practices for DHH students? (4) What are the challenges for DHH students and educators in learning science?

Methods

General background

This study used a qualitative method that relies on text and image data, involving unique data analysis steps and drawing on diverse designs (Creswell, 2014). According to McMillan & Schumacher (2006), qualitative research describes and analyses people's individual and collective social actions, beliefs, thoughts, and perceptions. The qualitative method used here utilizes specific protocols for recording data and analyzing information through multiple steps. A multiple case study design was chosen to examine several cases in their natural context and to understand their similarities and differences (Baxter & Jack, 2008). A case study design is appropriate for investigating science education for deaf learners from the perspective of educators as it can provide an in-depth understanding of participants' views, beliefs, and perceptions. Furthermore, the case studies are appropriate for exploratory and discovery-oriented research', to examine under-researched topics (Saxena, 2021).

In this study, science education practices in the following areas guided the data collection and analysis. Teaching, classroom science instruction practices, school support and intervention practices for science education, and teacher collaboration in special schools for DHH students were examined with the aim of improving inclusive science practices for these students. Data were gathered from five schools located in three regencies in Central Java, Indonesia, i.e., 3 schools from urban areas and 2 schools from suburban areas that provide educational services for DHH students. An inductive approach was followed to explore how special schools implement science education practices in different contexts and to draw subsequent conclusions by identifying patterns in the data obtained from different schools (Farquhar, 2012; Stake, 2010). The following subsections provide a detailed discussion of the selection of case study sites and participants and the collection and analysis of data.

Participants

Principals and secondary-level special education science teachers were purposefully selected as participants from five special schools that provide education for DHH students from three regencies in Regional V Banyumas, Central Java, Indonesia. A request for participation was sent to potential participants through a letter based on their role in the school as a school principal or science teacher. Four principals and six classroom science teachers for DHH students agreed to be interviewed (Table 1). Four teachers were observed while they taught science in the classroom. For ethical considerations, all participants were assured of confidentiality and anonymity. Additionally, every participant was informed about the study's aims and methods, any possible conflict of interest, institutional affiliations of the researcher, and source of funding, and gave consent to participate.

Table 1

Background Profiles of the Participants

Participants Code	Code Description	Gender	Age	Education Background	Level of Education	Teaching Experience*
P1	Principals	Female	42 y.o	Special Education	Master	15 years
P2	Principals	Male	45 y.o	Special Education	Master	17 years
P3	Principals	Male	43 y.o	Special Education	Bachelor	16 years
P4	Principals	Male	46 y.o	Special Education	Bachelor	20 years
T1	Science Teachers	Female	32 y.o	Mathematics	Bachelor	8 years
T2	Science Teachers	Male	41 y.o	Mathematics	Bachelor	15 years
T3	Science Teachers	Female	44 y.o	Mathematics	Bachelor	16 years
T4	Science Teachers	Female	25 y.o	Early Childhood	Bachelor	2 years
T5	Science Teachers	Female	40 y.o	Special Education	Bachelor	13 years
T6	Science Teachers	Male	45 y.o	Science	Bachelor	18 years

*Teaching DHH students or typically developing students

Data collection and analysis

The study was conducted from September to October 2017 using multiple data collection methods. The data collection process started with school visits, followed by science classroom observations in DHH schools, interviews with principals and teachers, and the collection of artifacts and available documents in the selected schools (i.e., lesson plans, worksheets, and textbooks). Data were collected through interviews with four principals and six secondary level-special education science teachers for DHH students. The interview process was conducted using the instrument in the interview guide (Table 2). The interviews were semi-structured and contained open-ended questions. Six secondary level-special education science teachers for DHH students had to answer all the questions (Q1-Q13) about the teaching-learning process related to science lessons for DHH students based on their knowledge and experiences, while the principals focused on questions Q11-Q12 related to learning support facilities in DHH schools. For the sake of confidentiality, the names of the participants were made anonymous by code P1-P4 for principals and T1-T6 for science teachers.

Table 2

Questions List for Participants

Question Code	Questions
Q1	Could you tell me about your educational background?
Q2	How long have you been teaching natural science in a special school for DHH students?
Q3	How to communicate with your students in classroom learning?
Q4	What is the curriculum used in a natural science classroom?
Q5	How about learning methods used in natural science learning so that DHH students can play an active role in learning?
Q6	What factors influence your students' learning strategies in science learning in class?
Q7	Do you have students who have difficulty learning and participating in learning in your class? What kinds of difficulties did they experience?
Q8	Based on your experience, what are the challenges of teaching DHH students in a science learning classroom?
Q9	Have you previously received courses related to special education?
Q10	What are the strategies you conduct to face the problems in science learning for DHH students?
Q11	What about the learning support facilities for DHH students in schools?
Q12	Has the government provided sufficient learning resources and other supporting facilities to assist you in creating inclusive science learning for DHH students?
Q13	Is there anything else you'd like to add?

The data obtained from each school visit were used to construct the initial descriptive narrative in response to the research questions. According to Kunene and Sepeng (2017), qualitative data analysis is a relatively systematic process of coding, categorizing, and interpreting data' to explain a single phenomenon of interest. The data gathered from interviews, observations, and artifact collection was triangulated to obtain a logical pattern to identify the current situation of science education practices for DHH students in the participating schools. To improve internal validity and reliability, peer examination and member checking were conducted (Morse, 2015). The latter involved drafting individual case study reports for each school and forwarding them to the schools for any comments and corrections.

Results and Discussion

The analysis of the collected data aimed to describe the participating schools' science practices for DHH students and to identify challenges in improving science education for such students in special schools aiming to give some kind of a guide for inclusive education of those students. To clarify the existing research findings, the data were organized and presented here according to the following themes: classroom practices, school support practices, and teacher collaboration.

Classroom practices

Various findings related to science instructional strategies in classroom practices were obtained from the selected schools (Table 3). The interviews revealed that all junior secondary schools for DHH students used a 'thematic' curriculum that combined all subjects into a single theme. The curriculum for the senior secondary schools for DHH students in the studied region was still under discussion by the relevant educational bureau at the time of data collection. Therefore, teachers in these schools referred to material that had already been taught in earlier grades, and they shared information with other schools. To meet DHH students' needs, teachers also implemented curriculum adaptation and modification.

Furthermore, there were differences among teachers regarding their teacher preparation programs and specialty areas. Of the six classroom science teachers for DHH students, three had completed a mathematics education program, and the other three had each completed an early childhood education program, a special needs education program, and a science education program. Classroom teachers in special schools generally teach all subjects, including science. New teachers who had not completed a science education or special education program experienced difficulties in teaching science concepts to DHH students due to their limited experience and knowledge regarding science and/or students with special needs. This negatively affected students' acquisition of scientific literacy based on the poor performance in science assessments taken by students. Teachers' ability to teach science subjects is crucial. The teachers' use of appropriate learning models could allow DHH students to learn and master science process skills (Ediyanto et al., 2018).

Overall, DHH students' classroom science learning activities were found to be the same as general education activities. DHH students' school learning activities prioritize language acquisition and skills development to prepare them to live independently in society. However, students are still taught other subjects, such as science, to enrich their knowledge and prepare them for the National Exam in Indonesia. Based on interviews with science teachers, it was found that all DHH students in the selected schools could read and write well in the classroom. However, the teachers said that students had limited scientific literacy and experienced difficulties in learning science because of their hearing constraints. The importance of literacy, asserts that it 'enables very young children to think, develop ideas, communicate, and reflect' (Andrews et al., 2004). However, it is well-documented that deaf learners generally experience significant difficulties in acquiring literacy skills (Andrews et al., 2004; Lang &

Albertini, 2001; Moores & Martin, 2006; Scheetz, 2004). Nevertheless, DHH students can improve their knowledge of science concepts through suitable learning models adapted to their abilities (Ediyanto et al., 2018).

Table 3

Interview Results Related to the Classroom Practices

Question Code	T1	T2	T3	T4	T5	T6
Q3	I'm trying to learn sign language to communicate with DHH students. However, students are also trained with lip reading.	Using sign language and lip-reading.	Sign language and using lip reading can be used to communicate.	I'm trying to learn sign language and found it difficult,	Students and teacher can use sign language and lip-reading.	We use sign language, lip-reading and written communication.
Q4	Thematic for junior high school.	Thematic for junior high school.	Thematic for junior high school.	Thematic for junior high school.	Thematic for junior high school.	Thematic for junior high school.
Q5	Learning is more emphasized on everyday skill and mastery of language.	Language acquisition and skills development. We also use various learning media based on visual characteristic,	We focus on contextual learning by conducting outdoor activities.	The important thing is how students can master the skills used in their lives.	Use more textbooks, pictures, slides, and lip-reading.	Science learning focuses on language acquisition and is essential for imparting skills relevant to everyday life.
Q6	Related to the student's abilities, schools' facilities, and teacher's abilities.	According to the students' and teachers' abilities.	Learning facilities and our abilities to teach DHH students.	Learning innovations and adaptations are carried out according to the circumstances of the students and the ability of the teacher.	According to the students' and teachers' abilities. Also, school facilities.	Learning strategies adapted to the student's ability of hearing, reading, and writing. Subsequently modified in accordance with the teacher's proficiency and the availability of learning support resources.

Based on classroom observations, it was found that students learned by paying attention to the teacher's explanation (sign language or lip-reading), rewriting the content being taught in their notebook, drawing models, grouping information in tables, and engaging in discussions and question-and-answer sessions with the teacher. When communicating with DHH students, all interviewed teachers try to use sign language, and some teachers combine it with lip reading and written communication. Teachers can use oral models or sign language models of communication with DHH students. Teachers whose students used lip-reading assumed that the technique could help students communicate with people in general because not all people can understand and use sign language. Regarding sign language, it was found that there were differences in the sign language used by students. Most of them tended to use local sign language that differs from one place to another. This can lead to misconceptions among students and the incorrect or inadequate acquisition of scientific concepts and literacy.

The findings from one classroom indicated that the DHH students lacked interest and motivation in science learning. It was because the time allocation for one science lesson is 70 minutes. The science material discussed is the concept of work and energy. At that time, the teacher taught directly without using supporting learning media. In this classroom, the students did not pay sufficient attention to the teacher's explanations and were bored during lessons. This is in line with the study conducted by Mahmutović & Hadžiefendić (2020) which found that deaf and hard of hearing students usually have a lower level of motivation to learn. Based on the teacher interviews, all teachers agreed that linking science concepts with relatable and straightforward daily life applications would be more meaningful for DHH students. The science, technology, and social learning approach can make science more useful, exciting, and appropriate for real-life applications, enabling DHH students to learn abstract science concepts (Atika et al., 2018). Therefore, teachers must be more creative in using different strategies that can help them impart science concepts to DHH students more easily and coherently.

Other findings related to learning activities show that different teachers use different strategies. Teachers used various learning media and subject matter content according to their availability in schools. A teacher used pictures, posters, and videos to explain science content to students, and some teachers allowed students to use Internet-enabled computers to explore their curiosity. In some classrooms, teachers asked students to engage in outdoor activities such as growing plants together. Teachers adjusted their methods to the science content being taught and relied on visual and hands-on activities appropriate for DHH students. According to Zainuddin et al. (2009), DHH students can learn through guided visualization and have strong visual communication abilities.

So, it is understandable that the teachers in our study have focused on visual stimuli tools as a strategy for teaching DHH students.

Furthermore, some studies have found that diverse learning methods, such as experimental and inquiry methods, can be applied to science learning for DHH students (Flores & Rumjanek, 2015; Gormally, 2017; Kurz et al., 2015; Zainuddin et al., 2009). Experimental and inquiry-based laboratory methods have been found to have increased DHH students' interest in science learning. Most DHH students who participated in experimental activities presented language refinement and increased self-esteem and self-confidence (Flores & Rumjanek, 2015). Moreover, inquiry-based laboratory learning could help DHH students enjoy hands-on activities and improve their ability to collaborate with peers (Gormally, 2017).

Based on DHH students' opinions gathered through the interview in the observed classrooms, they preferred learning science through experiments and demonstrations using simple props; however, none of the observed schools had science laboratories to support DHH students in learning and practicing science experiments as in regular schools. Regarding this, Ediyanto et al. (2017) asserted that the school environment could be a "learning laboratory". However, support facilities such as science laboratories have not been adapted and optimized for children with special needs in special schools. The lack of opportunity to conduct experiments in science laboratories has resulted in DHH students' low competence in science (Ediyanto et al., 2018). This has, in turn, hindered the development of their science process skills and their interest in science.

School support practices

All selected schools provided various in-class and out-of-class science support programs to implement inclusive science practices appropriate for DHH students' needs (Table 4).

Some support programs were common among all schools. Based on the observation in science learning, the learning process in one school was carried out according to a learning group system. Each learning group consisted of an average of five to seven students with a classroom teacher. This proportion is ideal based on the teacher-student ratio of 1:10 for students with mild disabilities (Ediyanto et al., 2017) since there are limitations in the number of teachers and classrooms available. If there are less than 10 students in the same grade, then that grade is combined with other grades at the same educational level. According to this system, students in the first, second, and third grades who are at one educational level (junior or senior secondary school) can be combined into one learning group. The other observed schools separated third-grade students to prepare them for the National Exam, which includes science as one of the subjects. All observed schools claimed that they had additional classes and extra learning materials for DHH students to prepare them for the National Exam, ensuring that they pass the exam with good results.

Table 4

Interview Results Related to the Schools Support Practices

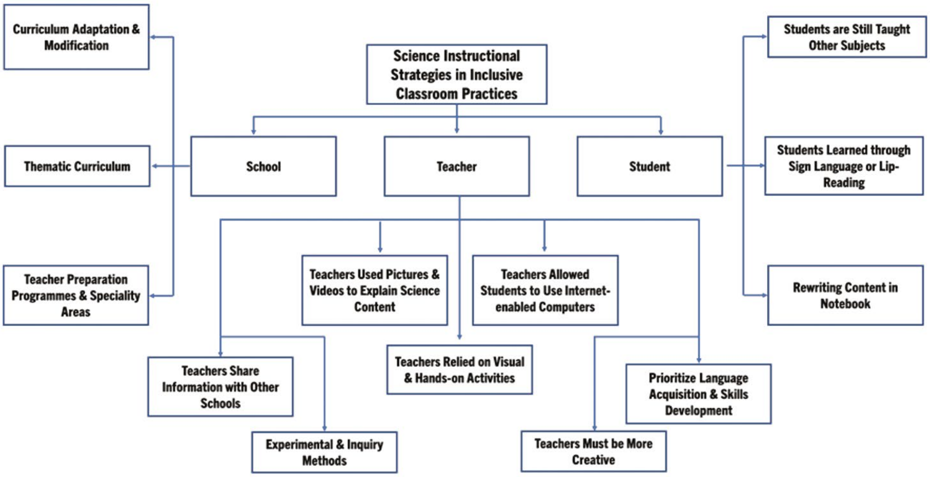
Question Code	T1	T2	T3	T4	T5	T6
Q11	Our school has a library and a few computers, which are not many.	There is a library in the school, but not many books and only a few computers.	We have books and some computer.	There are books and computers to support learning.	We need a science laboratory for practicum. In our school there are some books and few computers.	Learning support facilities include books and computers, but we do not have a science laboratory.
Q12	We have an interpreter. But not all time stand by at school.	There are interpreters who help students' self-development.	Yes, of course. As I mentioned earlier	An interpreter really helps the implementation of learning in my class.	Yes, of course.	Of course, as I mentioned before. And, we have an interpreter to help teacher and students communicate with each other.

The selected schools also had other learning support facilities, which included learning resources such as books and computers. However, it was observed that the schools had a limited number of books appropriate for DHH students' needs; students who wished to borrow a book usually had to wait a long time for the book to be returned by another student. Moreover, the issue of computer availability in special schools also needs to be addressed to ensure that all students' needs are met. Some schools only have a few computers, so students have to take turns using the computers during learning. The condition of such support facilities in the observed schools indicates the need for an improvement in science learning resources for DHH students to enhance their scientific literacy and science process skills. Appropriate support facilities can help teachers impart science concepts to DHH students more efficiently (Ediyanto et al., 2018).

Additionally, DHH students, who usually use sign language, generally have strong visual communication abilities (Zainuddin et al., 2009). The interviews with the four school principals revealed that each selected school had one sign language interpreter, although the interpreter was not always available at the school. During learning activities, these interpreters helped teachers interpret the sign language used by students. Another support facility was a speech-development program to improve DHH students' ability to speak clearly. This program was mandatory for DHH students in each of the observed schools. Meanwhile, science instructional strategies in school support practices can be shown as shown in Figure 1.

Figure 1

Science Instructional Strategies in School Support Practices



Teacher collaboration

All teachers need professional development opportunities to help them develop their knowledge, skills, and practice. Collaboration provides teachers with an opportunity to develop their expertise and knowledge, allowing them to share and adjust their expectations of all students (Basister & Kawai, 2018). Teacher collaboration in the observed schools included cooperation between not only teachers and educators from the same school but also those from other schools in different areas. Special education teachers or special school principals hold a meeting once a month—a teacher network forum for special education teachers—to share their pedagogical practices and experiences related to teaching DHH students. The teacher forum is the most familiar and widely used professional development practice for teachers in Indonesia because it covers all geographical areas, urban and rural (Tanang & Abu, 2014). In Indonesia, the teacher forum is a local government initiative aimed to empower teachers, improve teaching quality, and provide a platform for teachers to share their experiences, which can help them solve their problems in teaching activities (Supriadi, 1998).

Further, limitations in the availability of different learning media in the observed schools did not restrict teachers' creativity in devising effective learning methods for students. The teacher forum is intended to help teachers reform classroom practices, mediate in the development of teacher competencies, encourage innovation in the classroom and school management, and effectively collaborate with relevant professional organizations (Lai & Cheung, 2015). Table 5 shows the interview result of six teachers.

Table 5

Interview Results Related to the Teacher Collaboration

Question Code	T1	T2	T3	T4	T5	T6
Q9	No	No	No	No	Yes	No
Q10	In our regency, there is teacher forum that holds regular meetings once a month.	Share the problems with other teachers	Conducting teacher forum.	Collaborating with expert.	Following professional organizations, such as teacher forum for special education teachers,	We can collaborate with expert and following teacher forum programs.
Q13	It is important for prospective teachers to get courses or seminars about special needs students	Courses on inclusion or children with special needs must be studied in higher education.	Teachers need to attend seminars or training related current job.	It is necessary to learn knowledge about children with special needs and important to attend related seminars.	Teachers need to attend seminars to develop skills according to their current job.	Prospective teachers need to take courses on inclusion or children with special needs must be studied in higher education.

Regarding teacher preparation programs, all interviewed teachers agreed that courses related to inclusive practices needed to be added to such programs. Five of the six interviewed teachers claimed that they had limited knowledge and experience in teaching students with special needs. The interviewed teachers had only completed a general education program. They had not done any special or inclusive education courses, even though they were still recruited to teach in a special school. This can be proven by documenting interviews with teachers as shown in Figure 2.

Figure 2

Interviewing Teachers who Teach DHH Students (Documentation at Schools in Banjarnegara, Regional V Banyumas, Central Java, Indonesia)

Figure 3

Science Instructional Strategies in Teacher Collaboration

The interviewed teachers also expressed some other needs. They stated that they wanted more opportunities to participate in national and international training. Indonesia's Ministry of Education and Culture has established a center for teacher training focused on early childhood and special education (PPPPTK TK and PLB) that conducts teacher training at the national level. Additionally, the center also sends selected teachers to attend short courses at overseas universities. After receiving training from Widyaiswara (teacher trainers) and completing the overseas short courses, these teachers share their experiences with other teachers. Hopefully, this program will be sufficient to mitigate this disparity among teachers, even in rural areas. Meanwhile, science instructional strategies in teacher collaboration can be shown as shown in Figure 3.

Challenges Faced by DHH Students and Teachers

The analysis of the obtained data revealed the challenges faced by DHH students and educators in science learning (Table 6). Based on the discussion in the previous section, it can be said that the following intrinsic factors are liable to create challenges in providing inclusive science education for DHH students in the studied region. Low scientific literacy, differences in the sign language used in the teaching-learning process, and lack of interest and motivation among DHH students were found to be challenges faced in science learning for DHH students. These factors are inherent to students and are related to their science learning experience. Moreover, extrinsic factors related to aspects that are not under the control of DHH students also pose serious challenges. These factors include an incomplete senior high school science curriculum, limited science learning resources (i.e., books, computers, and science laboratories), and lack of teacher or educator qualifications.

Low scientific literacy is a key barrier for deaf learners in acquiring scientific knowledge, values, and skills. Science education can help learners develop the ability to think objectively, reason, investigate, reflect, analyze, and synthesize. Deaf learners should also be provided with the opportunity to develop these skills, which can improve their quality of life (Brice & Strauss, 2016). The current findings indicate that acquiring science education involves serious challenges for many deaf learners. However, these challenges may not be restricted to difficulties in the acquisition of scientific knowledge, values, and skills. They also involve low scientific literacy, differences in the use of sign language, lack of cognitive engagement, and limited resources, which affect deaf learners' acquisition of knowledge. Thus, deaf learners may understand scientific principles and concepts but may encounter difficulties in communicating their abilities effectively.

Regarding the challenges related to special education teachers' abilities to teach science to their students, these can be effectively addressed with support from the government in the form of teacher training for both in-service and pre-service teachers. It is also important to include additional courses at the university level, which can provide future teachers with the knowledge of appropriate methods to teach students with diverse and special needs (Pokhrel & Chhetri, 2021). Teachers need to be prepared to deal with a diverse group of students in schools, and relevant training should be provided not only in special education teaching programs but also in all other teacher preparation programs. Future research should conduct in-depth observations in other regions in Indonesia to determine the general condition of inclusive science education in a larger area.

Table 6

Interview Results Related to the Challenges Faced by Teachers

Question Code	Questions	T1	T2	T3	T4	T5	T6
Q7	Do you have students who have difficulty learning and participating in learning in your class? What kinds of difficulties did they experience?	DHH students lack motivation during learning.	Some students are not interested and feel bored in science learning.	Students have low scientific literacy and lack motivation.	Students are not interested and feel bored in science learning.	Students use different sign language during science learning and have low motivation.	Students have low scientific literacy and use different sign language.
Q8	Based on your experience, what are the challenges of teaching DHH students in science learning classroom?	Low scientific literacy, differences in the use of sign language.	Lack of cognitive engagement, which affect deaf learners' acquisition of knowledge.	Limited resources in science learning.	Lack of cognitive engagement.	Differences in the use of sign language	Low scientific literacy, differences in the use of sign language

It is hoped that the results of this study will serve as a guide for inclusive practices in science education for DHH students. Additionally, this study will be significant to special schoolteachers as it can provide practical strategies for addressing the diverse needs of DHH students in a special or inclusive classroom. The benefits associated with the various science education methods reported here can also provide schools in Indonesia and in other countries with an effective intervention strategy that can be adopted across all schools to generate enhanced learning outcomes. This could be beneficial not only for DHH schools but also for regular schools or even inclusive schools that accept students with similar conditions. This study may also be helpful for educational leaders and administrators in science education and special education as it can increase their awareness of different schools' strengths and weaknesses in designing suitable approaches to improve science education practices for DHH students. Finally, this study can also help future researchers identify appropriate teaching and learning practices for further investigation. Furthermore, more research at a larger scale and with more participants is required so that data on inclusive science learning practices more fully reflects Indonesia's situation.

Conclusions

Educating all learners to enable them to contribute to a world that is increasingly dependent on science and technology requires that science education includes DHH students. This study focused on science education practices in special schools for DHH students that help promote science for all students. The science education practices observed in the five selected schools indicate that teachers use various teaching strategies that rely on visual and hands-on activities. These activities are suited to meet DHH students' needs and prepare them for real-life challenges after completing secondary school. Existing support at the school level, such as the availability of sign language interpreters and the speech-development program, can improve the teaching-learning process for both teachers and DHH students. Regarding support facilities for science learning activities, the observed schools provide relevant textbooks and computers for students, although their numbers are still limited.

Acknowledgements

Ethics approval for this study was granted by (name of university withheld for the anonymous review process) Human Research Ethics Committee (2018).

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Obrazovna praksa u poučavanju prirodnih nauka za gluve i nagluve učenike u Indoneziji

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Uvod: Nastavni plan i program za gluve učenike uglavnom je, tradicionalno, dominantno uključivao usvajanje jezika na račun drugih akademskih predmeta. Obrazovanje ovih učenika, trenutno, uključuju i druge predmete, poput prirodnih nauka, kako bi obogatili njihovo znanje u vezi sa životom ljudi. *Cilj:* Ova studija ima za cilj da opiše primenu obrazovne prakse u oblasti obrazovanja prirodnih nauka i identifikuje izazove u poboljšanju ove oblasti obrazovanja u specijalnim školama za gluve i nagluve (DHH) učenike kao vodič za unapređenje inkluzivnog obrazovanja ovih učenika. *Metode:* Učesnici su bili četiri direktora i šest nastavnika prirodnih nauka iz pet DHH škola, koristeći namerno uzorkovanje u pet škola koje pružaju obrazovanje za DHH učenike u tri regije V Banjumas, Centralna Java, Indonezija. Podaci su prikupljeni putem intervjua, terenskih opservacija i artefakata. *Rezultati:* Nastavnici koriste različite nastavne strategije i oslanjaju se na vizuelne i praktične aktivnosti prilikom obrazovanja DHH učenika. Škole obezbeđuju podršku tumača za znakovni jezik i programe za razvoj govora kao podršku, kako nastavnicima, tako i učenicima DHH. Svim nastavnicima je potrebno profesionalno usavršavanje u nastavnom radu kako bi razvili svoju stručnost za podučavanje učenika DHH-a. Utvrđeno je da su implementacija politike, strategije nastave, resursi i kvalifikacije nastavnika ekstrinzični faktori. *Zaključak:* Neophodno je obezbediti podršku vlade pri uključivanju u relevantne programe obuke i pripreme nastavnika koji su edukovani za rad u specijalnom ili inkluzivnom obrazovanju, kroz usavršavanje univerzitetskog obrazovanja za sve buduće nastavnike.

Ključne reči: gluvi i nagluvi učenici, obrazovne prakse, inkluzija, prirodne nauke

PRIMLJENO: 26.11.2022.
REVIDIRANO:17.05.2023.
PRIHVAĆENO:07.07.2023.