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IDENTIFYING THE DEFICIENCY OF SCIENTIFIC LEXICON IN PAKISTAN SIGN LANGUAGE: INSIGHTS OF PRIMARY SCIENCE TEACHERS OF DEAF

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ABSTRACT

This study examines the vocabulary gaps in the Pakistan Sign Language (PSL) by identifying scientific terms that lack standardized signs, from the 5th-grade Punjab science textbook, seeking feedback from science teachers, and exploring the strategies they employ when no sign is available. A thorough content analysis of the book found that a large proportion of key scientific words, particularly technical and scientific concepts, do not have existing signs in PSL. A multistage proportionate random sampling method was employed to select 101 science teachers of hearing-impaired students from 11 districts across 5 randomly selected divisions of Punjab. The teachers' responses of validated these gaps and provided insight into the coping strategies they use in teaching, such as fingerspelling, skipping the word, or using alternative sign. Such strategies, although effective, such strategies are likely to impact effective communication and compromise conceptual understanding of Deaf and Hard-of-Hearing (DHH) students. A total of 51 scientific words were found to be lacking in PSL highlighting the urgent need to create standardized signs. The research concludes that addressing these lexical gaps is crucial to ensure inclusive science education. It also suggests collaborative sign creation, the incorporation of new words into teacher education, visual learning tool development, and policy initiatives to facilitate continuing the extension of PSL. The results provide a foundation for improving accessibility and equity in science education for DHH students in Pakistan.

INTRODUCTION

Sign language is a cornerstone of the educational and cognitive progress of Deaf children. Being a completely accessible and natural language, it supports early language acquisition, fosters critical thinking, and enables academic success in multiple fields. Mayer and Trezek (2023) claim that sign languages play a crucial role not in communication but also in building the conceptual knowledge needed for academic success in literacy and STEM fields. Deaf students who lack early and continuous exposure to a natural sign language face a higher risk of language deprivation, which can lead to long-term cognitive and educational setbacks (Murray, Hall, & Snoddon 2019).

Research indicates that Deaf children who start learning sign language in life develop linguistic and cognitive abilities that match or even surpass those of hearing children (Van Staden, Badenhorst, & Ridge 2010). Besides supporting learning, sign language also promotes a strong Deaf identity and school and societal belonging (Singh & Dubey, 2025). Thus, the introduction of sign language in Deaf education is not so much an accessibility matter but a necessary requirement to guarantee equal and effective teaching.

The contribution of Pakistan Sign Language (PSL) in making science education at the primary level inclusive in Pakistan cannot be overestimated. Despite the importance it holds, the absence of a standard scientific vocabulary in PSL makes it very difficult for the teachers and the learners alike. They tend to resort to bad practices such as fingerspelling, leaving out unknown words, or coming up with improvisational signs, all of which hinder conceptual clarity and influence the success of science teaching (Ali, Kiani, & Zia, 2023; Iqbal, Kanwal, & Zafar, 2022). Recent efforts, like Deaf Reach's PSL digital dictionary and visual guides, have sought to fill this gap by enhancing subject-specific terminology access for students and teachers alike (Deaf Reach,). Additionally, field evidence from EdTech Hub (2020) indicated significant learning increase among Deaf students who used PSL-based video science lessons. However, the ongoing lack of a unified scientific vocabulary, as well as regional differences in sign use, hinders consistent and representative science education (Abid, Jan, & Majeed, 2018; Akram & Bashir, 2019).

Deaf and Hard-of-Hearing (DHH) students across the world are challenged by science education as there are no standard signs for technical vocabulary. Research indicates that numerous scientific terms in ASL are not adequately signed, and thus fingerspelling and improvisation are used, which obstructs understanding (Boerner, 2021; Yin et al., 2024). Limited STEM education and emphasis on rote memorization among interpreters' influence understanding as well (Kurz et al., 2023; Braun et al., 2018). These difficulties emphasize the immediate necessity for scientific standardization in sign languages' vocabularies.

Statement of the Problem

The lack of standardized signs for most scientific terms in Pakistan Sign Language (PSL) is a serious barrier to successful science education for Deaf students in the primary years. Due to Lacking proper signs, teachers are frequently unable to explain fundamental scientific terms clearly, as a result they rely on fingerspelling, skipping the word and use alternative sign as strategies. Such workaround can cause confusion and prevent students from understanding fundamental scientific concepts. In spite of the impact on education, a noticeable lack is found of systematic research to find out which science words have no PSL signs, especially in primary science education. This research addresses this gap by focusing on the representation of the 5th-grade science curriculum within PSL and aims to compile a list of scientific concepts with no standardized signs, as well as recording the approaches used by teachers in addressing in such gaps when teaching.

Justification of the Study

This study is important because it focuses on what special education teachers who teach science to Deaf students have experienced and learned. These teachers, who work in classrooms every day, can identify specific words that cause problems when there's no sign for them. By looking at what they've experienced firsthand, the research will create a checked list of missing science terms—a key tool for people working on development of sign language. Besides helping make new signs, this study will help to improve how classes are planned, train interpreters better, and create a learning space that includes everyone and helps Deaf students do well in school especially in science education.

Objectives of the study

1. To analyze the 5th-grade science textbook to identify scientific terms that lack standardized signs in Pakistan Sign Language (PSL).

2. To gather 5th-grade science teachers' input on scientific terms they find lacking PSL signs.
3. To investigate the alternative strategies teachers, use when encountering lexical gaps during science instruction.
4. To compile a list of missing scientific terms in PSL based on textbook review and teacher input to guide future sign development.

Literature review

Sign language and science education

Sign language is essential in making science education accessible for Deaf and Hard-of-Hearing (DHH) students, particularly with the abstract and technical content of scientific terminologies. Most scientific terms have no standardized signs, and educators are compelled to use fingerspelling or ad hoc signs, which can limit understanding and conceptual clarity (Boerner, 2021). Research identifies that improvised or inconsistent signs adversely affect students' knowledge and interest (Braun et al., 2018; Kurz et al., 2023). International initiatives, including the ASL STEM Wiki, underscore the need for the enrichment of sign language vocabularies to enhance science learning opportunities for DHH students (Yin et al., 2024).

Challenges with Abstract and Technical Vocabulary

Deaf learners continue to struggle with abstract and technical terms in science. Kurz, Schick, and Hauser (2023) point out that learning contexts for science, especially informal and non-formal learning, tend to emphasize memorization of vocabulary instead of encouraging rich conceptual knowledge. Additionally, Braun et al. (2018) find that most interpreters receive no science specialized training and this results in unstandardized signing /interpretation as well as confusion to the learner. These issues impede accessible science education for deaf students and restrict their engagement and achievement in STEM.

Lexical Gaps in Sign Languages

There are also lexical gaps in sign languages where there are no standardized signs for academic or technical terms, and this can complicate commun ication for Deaf individuals. As per Mudd et al. (2022), without shared context, incoherent use of signs persists. Overseas work, such as the ASL STEM WIKI And research into Auslan, documents over-reliance on fingerspelling and ad hoc gestures for technical terms (Yin et al., 2024; Major et al., 2012), increases cognitive load and decreases comprehension. Such gaps hinder Deaf learners' understanding and limit access to quality learning in subjects like science.

Lexical Gaps in Pakistan Sign Language

Lexical gaps of Pakistan Sign Language (PSL) are instances of absence signs, which are not standard or universally accepted for academic and technical vocabulary especially in sciences. Moreover, PSL, which still has a limited vocabulary, is mainly used as the mode of communication within the Deaf community in Pakistan, especially in schools. Hameed and Sulman (2023) have found that the Deaf students at school experience significant communication barriers in the absence of signs, the overuse of improvisation, and fingerspelling of educational materials. These differences are indications of the crucial lexical gap that affects the capability of understanding and successful participation. Similarly, Afzaal and Amjad (2024) determined that hearing students, and even university students, only know the common signs, as the development of PSL vocabulary is limited and thus, the spreading of the vocabulary is also limited. The findings of the study emphasize the necessity of finding and addressing the lexical gaps of the PSL in order to make the teaching of Deaf students more inclusive and efficacious in the whole of Pakistan.

Teachers' Perceptions and Role in Identifying Gaps

Teachers are critical stakeholders in the identification and bridging of lexical gaps within sign language, particularly in educational settings. In Pakistan, Ali, Kanwal, and Ishrat (2023) investigated the perception of teachers of students

with hearing impairments regarding the inconsistency and lack of standardization in Pakistan Sign Language (PSL), specifically in academic vocabulary These researchers note that teachers frequently encounter difficulties when there are no standard signs available for technical terms in particular subjects, forcing them to use fingerspelling or improvised signs—strategies that prevent conceptual understanding for Deaf students. Worldwide, Pizzo (2018) emphasized teachers' proactive role of expanding American Sign Language (ASL) vocabulary through intentional and deliberate vocabulary instruction. Such practice is required in the improvement of early language acquisition and success. The same applies to Rodrigues et al. (2022), who discovered that Portuguese and Swedish teachers know about the visual-cognitive skills of Deaf and hard-of-hearing students but lack the capability to assist them because they are not well trained in sign language and subject-related signs. These studies in aggregate highlight that teachers not only have the potential to observe first-hand effects of lexical gaps but also are prime informants and co-designers of inclusive, accessible sign language learning resources for education.

Strategies Used to Address Missing Signs

when sign languages lack standardized terminology for technical or academic vocabulary, teachers and interpreters' resort to fingerspelling, gesture description, or improvised signs to express meaning. Even though these interventions are temporary, they promote different interpretations and elevate cognitive overload on the Deaf learners, thereby affecting their comprehension (Major et al., 2012; Semunyu & Rushahu, 2023). These coping strategies reflect a wider disparity in specialized lexicon resources and reinforce the need for standardized sign creation to provide uniform and equal education for Deaf learners.

Gap in Literature and Contribution of Current Study

Research into the development of Pakistan Sign Language (PSL) are still limited, especially concerning scientific and academic terms. Although organizations like the Pakistan Association for the Deaf (PAD), Deaf Reach, and the National Institute of Special Education (NISE) have developed lexicons for PSL with as many as 7,500 words, these attempts have been primarily on the everyday language and not on curriculum-based subjects such as science and mathematics (Hameed & Sulman, 2023; Afzaal & Amjad, 2024).

Technical progress, for example, gesture-based PSL recognition with machine learning (Mirza et al., 2022; Saqib, 2019), has supported assistive technology but not the linguistic or pedagogical issues in developing new signs for educational purposes. Consequently, there are two significant gaps yet to be met: (1) no PSL-specific research on lexical gaps in academic disciplines—specifically science at the primary level—and (2) no participatory, community-initiated processes for creating standardized educational signs.

This research attempts to fill these gaps by recognizing missing scientific vocabulary in the 5th-grade science subject. Despite increasing efforts to promote inclusive education, important scientific terms still have no standard signs in PSL. This forces teachers and interpreters into using fingerspelling or improvised gestures, which compromises instructional accuracy and restricts Deaf and Hard-of-Hearing (DHH) students' comprehension. The paper aims at developing the list of missing terms and bringing out a list that could guide future sign creation efforts toward better access to science education for DHH learners.

Methodology

This study employed a quantitative, descriptive research design to determine missing scientific vocabulary in Pakistan Sign Language (PSL) at grade 5 level. Teachers of the 5th grade/class of hearing-impaired students formed the study population. A multistage proportionate random sampling was employed to select 101 science teachers of hearing-impaired students from 11 districts of 5 randomly selected divisions of Punjab.

A 70-word checklist was designed to find out scientific terms from the 5th-grade Punjab science textbook that does not have standardized signs in Pakistan Sign Language (PSL). The preliminary list of vocabulary was derived via content analysis of the textbook and narrowed down by expert consultation. Each term was subsequently cross-referenced with available PSL materials, such as dictionaries developed by the Directorate General of Special Education (DGSE, 2007) and the Family Educational Services Foundation (FESF, 2014). The final checklist only contained those terms with no standardized signs. Teachers were asked to indicate whether a sign existed for each term. If not, they were further asked to specify which of the following three strategies they used in the classroom: fingerspelling, skipping the word, or using an alternative sign.

For the purposes of this study, a scientific term was considered to have a recognized sign in Pakistan Sign Language (PSL) if at least 70% of the teachers reported its existence. This benchmark was used to distinguish between widely accepted signs and those that may be inconsistently used.

Ethical Considerations

The study strictly adhered to established ethical guidelines to safeguard the rights, dignity, and privacy of all participants. Informed consent was obtained prior to participation, and confidentiality was maintained by ensuring that no personally identifiable information was included in any form of data reporting.

Data Analysis

Table .1: Demographic information of the teachers.

Variables		Frequency	Percentage
Gender of Teachers	Male	29	28.7%
	Female	72	71.3%
	Total	101	100%
Age of Teachers	20-30	23	22.8%
	31-40	58	57.4%
	41-50	10	9.9%
	51-60	10	9.9%
	Total	101	100%
Qualification of Teachers	BS / M. A	48	47.5%
	M.Phil.	34	33.7%
	B.Ed./M.Ed.	19	18.8%
	Total	101	100%
	J.S.E.T	62	61.4%

Designation of Teachers	S.S.E.T	39	38.6%
	Total	101	100%
Teaching Experience	01-05	26	25.7%
	06-10	30	29.7%
	11-15	24	23.8%
	16-20	11	10.9%
	20+	10	9.9%
	Total	101	100%
Level of Proficiency in PSL	Beginner	15	14.9%
	Intermediate	56	55.4%
	Advance	30	29.7%
	Total	101	100%
How Often Do You Consult PSL?	Often	50	49.5%
	Sometimes	43	42.6%
	Rarely	08	7.9%
	Total	101	100%
Do You Have a Sign Language Diploma?	Yes	50	49.5%
	No	51	50.5%
	Total	101	100%
Duration of Diploma	3 months	86	85.1%
	6 months	15	14.9%
	Total	101	100%

The majority of participating teachers were female (71.3%), reflecting the gender distribution in Punjab's Special Education Department. Most were aged 31–40 years (57.4%) and held BS or MA degrees (47.5%), the standard qualifications for teaching posts. Junior Special Education Teachers (61.4%) formed the largest group, as their positions are more common. Most had 6–10 years of experience (29.7%), indicating moderate professional exposure. Over half (55.4%) rated their PSL proficiency as intermediate, and 49.5% reported frequent use of PSL. Similarly, 49.5% held a diploma in sign language, primarily from short-term departmental training programs.

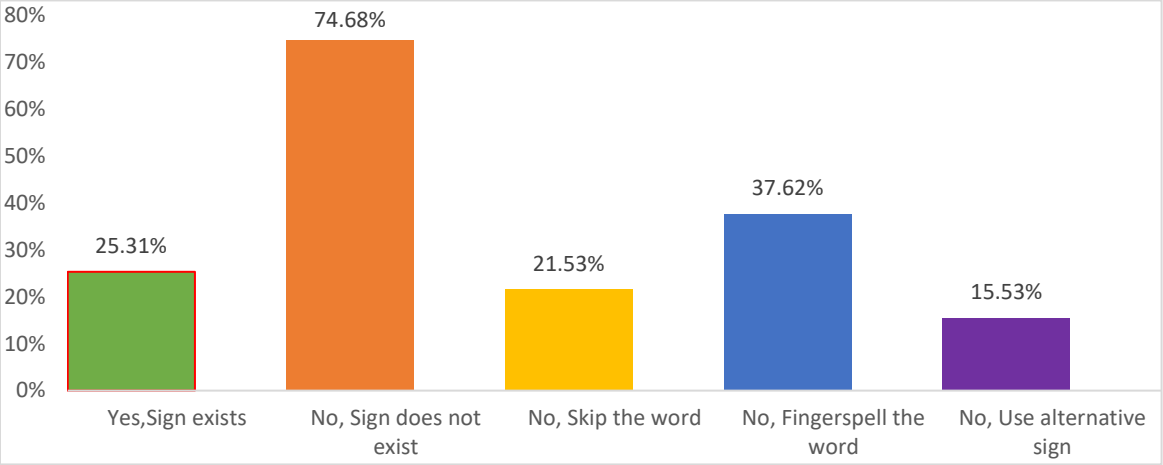
Identification of Missing Scientific Terms
To identify missing scientific terms in the PSL lexicon, the checklist was organized chapter-wise according of the 5th-grade Punjab science textbook. This structure enabled targeted analysis of vocabulary gaps, as data were analyzed chapter by chapter to determine which scientific concepts lacked standardized signs and to highlight areas requiring sign language development.

Chapter-1 Classification of Living Organisms

Table .2: Summary of Sign Availability for Chapter 1 Scientific Terms

Words	Sign Exists (%)	Fingerspell the word (%)	Skip the word (%)	Alternative Sign (%)
Monera	11.9	53.5	26.7	7.9
Protista	13.9	18.8	33.7	33.7
Paramecium	35.6	14.9	24.8	24.8
Spirogyra	14.9	39.6	15.8	29.7
Fungi	11.9	53.5	20.8	13.9
Yeast	18.8	35.6	39.6	5.9
Rhizopus	16.8	35.6	27.7	19.8
Monocot	20.8	44.6	13.9	20.8
Dicot	16.8	43.6	18.8	20.8
Cotyledon	11.9	47.5	14.9	25.7
Molluscs	6.9	56.4	25.7	10.9
Sponges	21.8	44.6	12.9	20.8
Mammals	89.1	10.9	0.0	0.0
Biodiversity	10.9	44.6	36.6	7.9
Amphibians	84.2	4.0	5.9	5.9
Reptile	18.8	54.5	26.7	0.0

The table .2 shows that a majority of the 16 scientific terms from Chapter 1 lack standardized signs in Pakistan Sign Language (PSL), leading teachers to rely on alternative communication strategies. Words like Monera, Fungi, Molluscs, and Reptile were most commonly finger-spelled, reflecting the absence of formal signs. Similarly, terms such as Protista, Paramecium, Spirogyra, and Biodiversity were often skipped or replaced with improvised alternatives. In contrast, the table indicates that only a few terms Mammals (89.1%) and Amphibians (84.2%) had widely recognized and used signs among teachers.



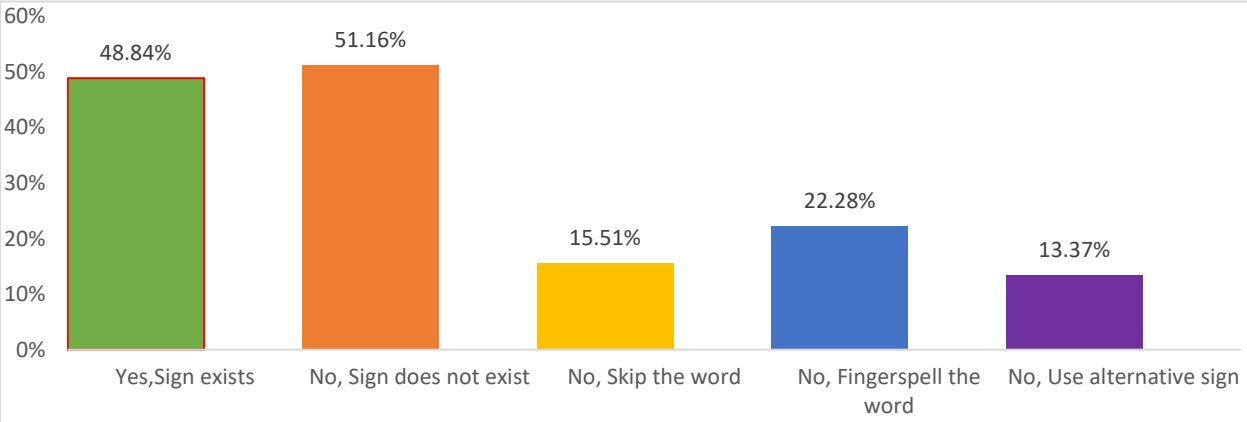
The chart shows that only 25.3% of the 16 scientific terms had existing PSL signs, while 74.7% lacked them. Teachers commonly used fingerspelling (37.6%), skipping (21.5%), or alternative signs (15.5%) to address these gaps.

Chapter-2 Mircoporganisms

Table .3: Summary of Missing Words from Chapter 2 - Micro-organisms

Words	Sign Exists (%)	Fingerspell the word (%)	Skip the word (%)	Alternative Sign (%)
Bacteria	82.2	4.0	9.9	4.0
Habitat	11.9	36.6	31.7	19.8
Decompose	15.8	42.6	12.9	28.7
Diarrhea	90.1	0.0	6.9	3.0
Mumps	13.9	44.6	16.8	24.8
Virus	79.2	5.9	14.9	0.0

The table .3 shows that most respondents recognized signs for Bacteria (82.2%), Diarrhea (90.1%), and Virus (79.2%), indicating these terms are well established in PSL. In contrast, Habitat (11.9%), Mumps (13.9%), and Decompose (15.8%) had very low sign recognition, leading teachers to rely heavily on fingerspelling and alternative signs. Notably, Habitat and Mumps were finger-spelled by over 44% of teachers, highlighting a significant lexical gap for these terms.



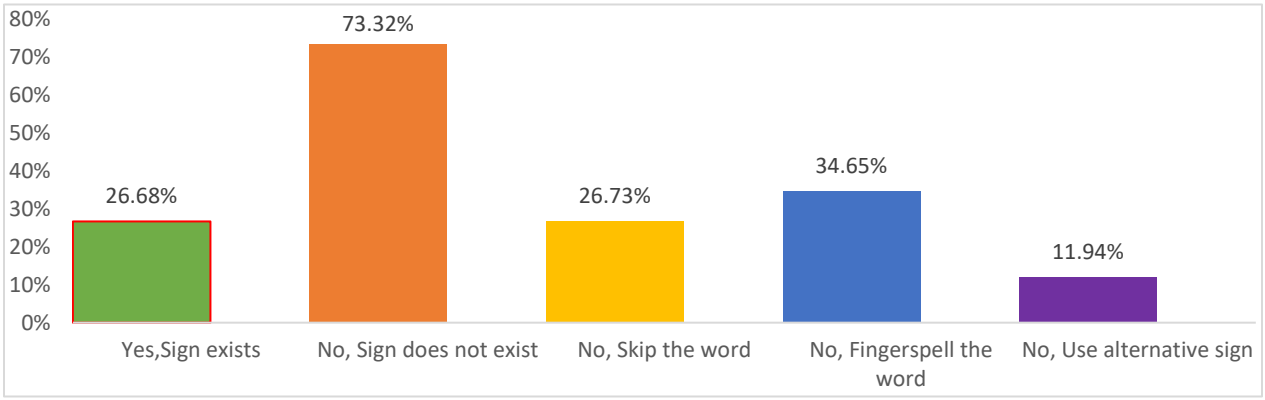
The chart shows that 48.84% of teachers reported existing signs for the six terms, while 51.16% indicated no sign availability. Among alternatives, 22.28% used fingerspelling, 15.51% skipped the word, and 13.37% used alternative signs, reflecting notable gaps in PSL vocabulary.

Chapter-3 Flowers and seeds

Table .4: Summary of Missing Words from Chapter 3- Flowers and seeds

Words	Sign Exists (%)	Fingerspell the word (%)	Skip the word (%)	Alternative Sign (%)
Pollination	82.2	6.9	4.0	6.9
Sepal	11.9	31.7	34.7	21.8
Carpel	18.8	37.6	29.7	14.9
Pedicel	4.0	55.4	33.7	6.9
Anther	21.8	38.6	14.9	24.8
Filament	13.9	47.5	19.8	18.8
Ovule	15.8	49.5	18.8	15.8
Stigma	19.8	34.7	29.7	15.8
Ovary	10.9	32.7	50.5	5.9
Zygote	9.9	54.5	23.8	11.9
Embryo	29.7	21.8	30.7	17.8
Micropyle	11.9	44.6	43.6	0.0
Radicle	20.8	43.6	27.7	7.9
Gramseed	11.9	43.6	44.6	0.0
Miazseed	9.9	32.7	37.6	19.8
Agriculture	79.2	6.9	4.0	9.9
Reproduction	82.2	6.9	6.9	4.0

The table .4 shows teachers' responses on 17 scientific terms from Chapter 3, "Flowers and Seeds," highlighting that signs exist for common terms like "Reproduction," "Pollination," and "Agriculture" (over 79%). However, less familiar terms such as "Pedicel," "Micropyle," "Gramseed," and "Zygote" lacked standardized signs, leading teachers to rely mainly on fingerspelling or skipping the words during instruction.



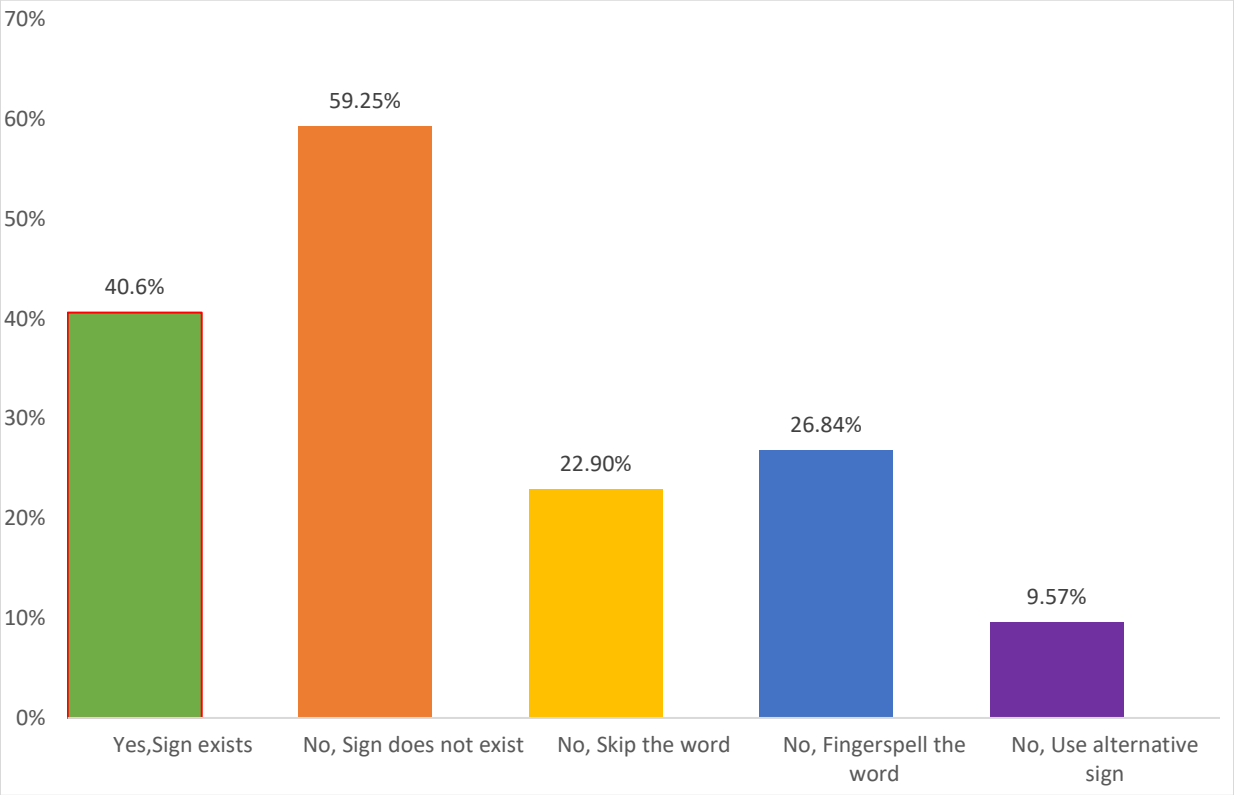
The chart shows that only 26.68% of teachers reported existing PSL signs for Chapter 3 terms, while 73.32% noted no sign availability. Teachers mostly used fingerspelling (34.65%), skipping (26.73%), or alternative signs (11.94%) as substitutes.

Chapter-5 physical and chemical changes of matter

Table .5: Summary of Missing Words from Chapter 5- Physical and chemical changes of matter

Words	Sign Exists (%)	Fingerspell the word (%)	Skip the word (%)	Alternative Sign (%)
Evaporation	90.1	6.9	4.0	3.0
Decay	96.0	4.0	0.0	0.0
Vapours	17.8	34.7	39.6	7.9
Solute	13.9	49.5	25.7	10.9
Dissolve	12.9	24.8	28.7	33.7
Stirring	10.9	45.5	31.7	11.9
Dilute	18.8	34.7	46.5	0.0
Combustion	17.8	35.6	27.7	18.8
Condensation	87.1	5.9	6.9	0.0

The table .5 indicates that concepts like "Decay" (96%), "Evaporation" (90.1%), and "Condensation" (87.1%) have standardized signs in PSL. In contrast, several terms from Chapter 5—such as "Solute," "Stirring," "Dissolve," and "Combustion"—lack standardized signs, prompting teachers to use fingerspelling or omit these terms during instruction.



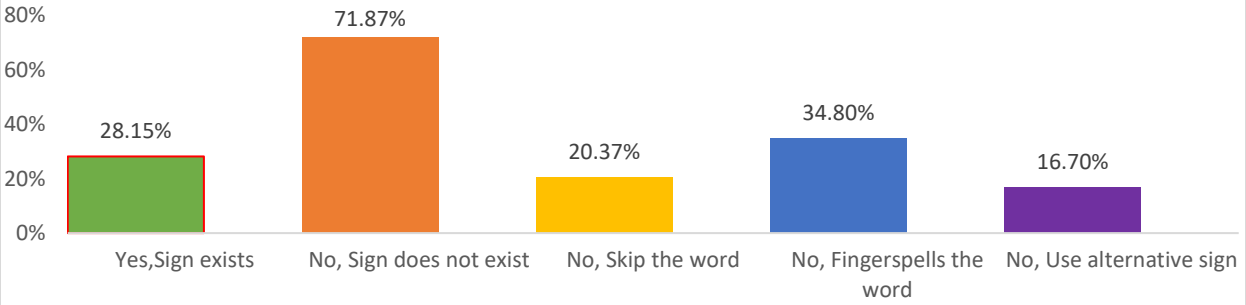
The chart shows that only 40.6% of teachers reported standardized PSL signs for the 9 scientific terms from Chapter 5, while 59.4% indicated no sign availability. To compensate, 26.84% used fingerspelling, 22.90% skipped the word, and 9.57% used alternative signs.

Chapter-6 Light and sound

Table .6: Summary of Missing Words from Chapter 6- Light and Sound

Words	Sign Exists (%)	Fingerspell the word (%)	Skip the word (%)	Alternative Sign (%)
Transparent	17.8	36.6	21.8	23.8
Reflection	96	0	01	03
Disrupt	14.9	35.6	41.6	7.9
Luminous	14.9	14.9	46.5	23.8
Opaque	22.8	19.8	42.6	14.9
Translucent	18.8	17.8	50.5	12.9

The table .6 presents teachers' responses on seven scientific terms from the 5th-grade "Light and Sound" chapter. "Reflection" has a recognized sign in PSL (96%). In contrast, terms like "Transparent," "Disrupt," "Luminous," "Opaque," "Translucent," and "Propagation" lack standard signs. Teachers often use fingerspelling or skip these terms during instruction.



The chart shows that 28.15% of teachers reported existing signs for the 7 terms, while 71.87% indicated no signs in PSL. To cope, 34.80% used fingerspelling, 20.37% skipped the word, and 16.70% used alternative signs.

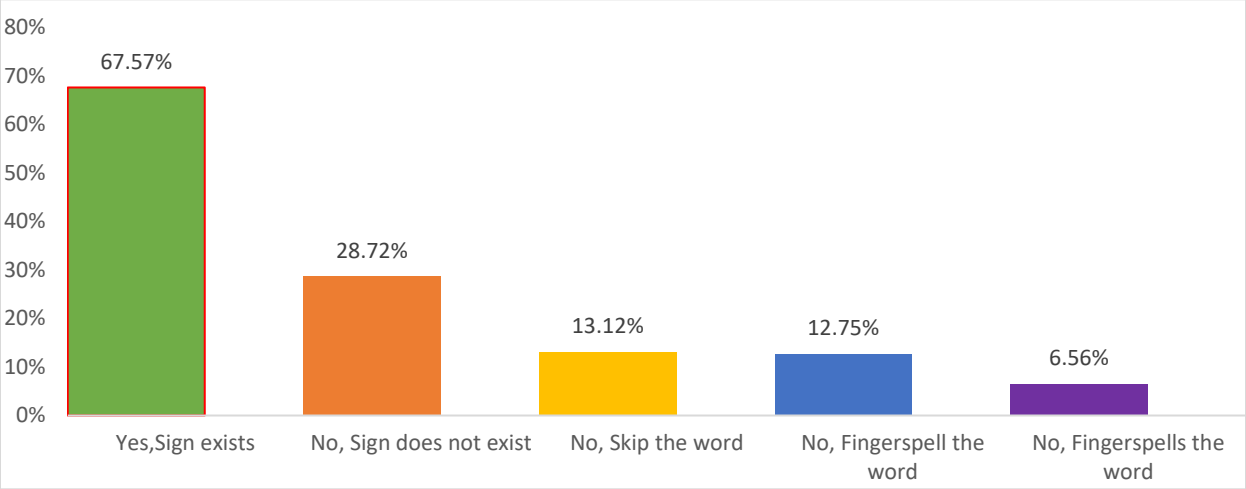
Chapter-7 Electricity and Magnetism

Table .7: Summary of Missing Words from Chapter 7- Electricity and Magnetism

Words	Sign Exists (%)	Fingerspell the word (%)	Skip the word (%)	Alternative Sign (%)
Atom	78.2	6.9	14.9	0
Static	94.1	04	01	01
Magnetism	85.1	03	05	6.9
Particle	18.8	49.5	11.9	19.8
Electric Current	86.1	04	9.9	0

Repel	13.9	25.7	39.5	20.8
Insulator	84.2	8.9	6.9	0
Electromagnet	80.2	03	12.9	04

The table .7 presents teachers' responses on eight scientific terms from the 5th-grade "Electricity and Magnetism" chapter regarding their availability in Pakistan Sign Language (PSL). Teachers reported that signs exist for key terms such as "Static," "Electric Current," "Magnetism," "Insulator," "Electromagnet," and "Atom," each with over 75% sign availability. In contrast, terms like "Particle" and "Repel" had less than 20% availability in PSL.



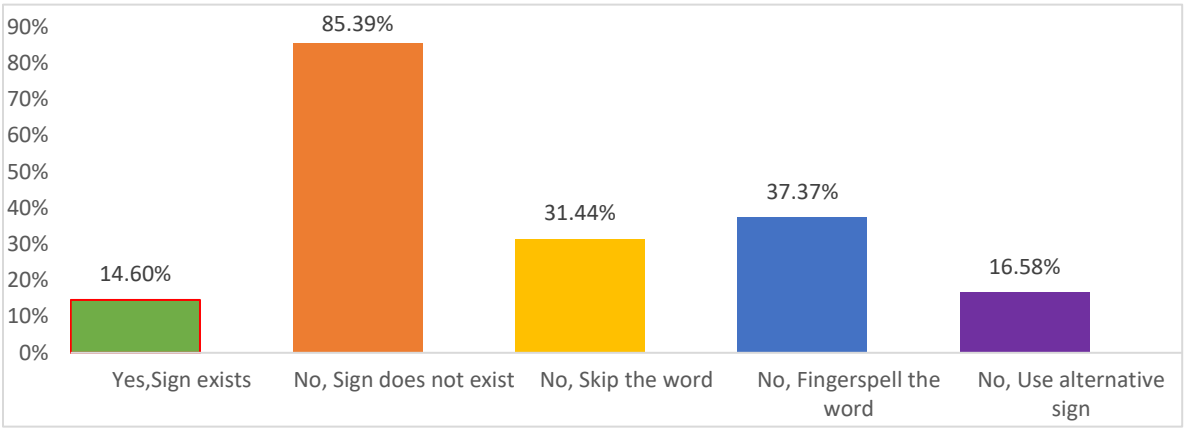
The chart shows that 67.57% of teachers reported signs exist for the 8 terms in PSL, while 28.72% indicated no sign availability. To cope, 13.12% skipped the word, 12.75% used fingerspelling, and 6.56% used alternative signs during instruction.

Chapter-8 Structure of the Earth

Table .8: Summary of Missing Words from Chapter 8- Structure of the earth

Words	Sign Exists (%)	Fingerspell the word (%)	Skip the word (%)	Alternative Sign (%)
Geologist	15.8	24.8	43.6	15.8
Mantle	19.8	37.6	24.8	17.8
Core	13.9	25.7	37.6	22.8
Texture	8.9	37.6	43.6	9.9

The table .8 presents teachers' responses on four terms from the 5th-grade "Structure of the Earth" chapter, showing limited PSL sign availability. Only 15.8% reported a sign for "Geologist," 19.8% for "Mantle," 13.9% for "Core," and 8.9% for "Texture." In most cases, teachers used fingerspelling or skipped the terms during instruction.



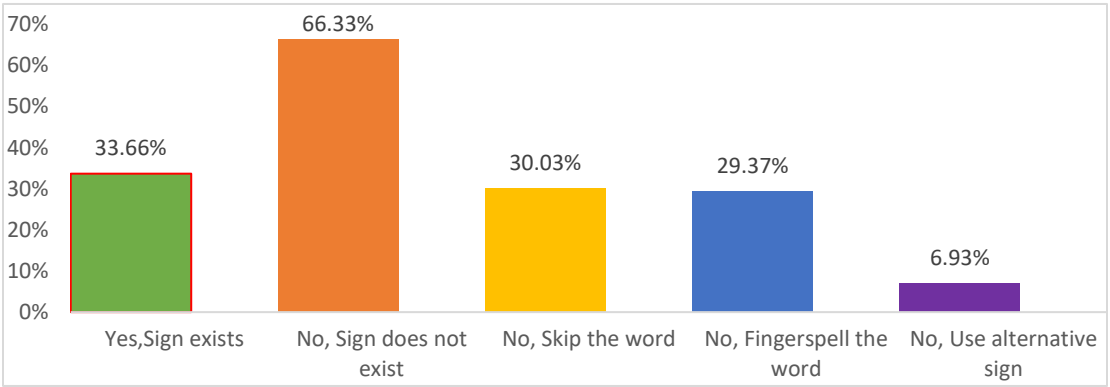
The chart shows that only 14.60% of teachers reported signs for the four terms from Chapter 8 "Structure of Earth" in PSL, while 85.39% indicated no sign availability. To address this, 31.44% skipped the word, 37.37% used fingerspelling, and 16.58% used alternative signs.

Chapter-9 Space and satellites

Table .9: Summary of Missing Words from Chapter 8- Space and Satellites

Words	Sign Exists (%)	Fingerspell the word (%)	Skip the word (%)	Alternative Sign (%)
Spacecraft	10.9	34.7	45.5	8.9
Spying	6.9	52.5	32.7	7.9
Satellite	83.2	3	9.9	4

The table .9 presents teachers' responses on three terms from the 5th-grade "Space and Satellites" chapter. While 83.2% reported a sign for "Satellite," only 10.9% and 6.9% confirmed signs for "Spacecraft" and "Spying," respectively. In most cases, teachers used fingerspelling or skipped the terms due to lack of standardized signs.



The chart shows that 33.66% of teachers reported signs for the four terms from Chapter 8 "Structure of Earth" in PSL, while 66.33% reported no sign availability. To manage this, 30.03% skipped the word, 29.37% used fingerspelling, and 6.93% used alternative signs.

Findings

This study aimed to identify missing scientific terms in Pakistan Sign Language (PSL) from the 5th-grade Punjab science textbook, gather teachers' input on unavailable signs, examine the alternative strategies they use, and compile a list of missing vocabulary to guide future sign development efforts.

The chapter-wise analysis of the 5th-grade science textbook revealed a substantial number of scientific terms that lack standardized signs in PSL. Overall, only a limited percentage of the terms had existing signs, and the majority of technical and subject-specific vocabulary had no formally recognized signs. For instance, only 25.3% of terms from Chapter 1, 26.68% from Chapter 3, and as low as 14.6% from Chapter 8 were reported to have existing PSL signs. This evaluation was based on the 75% benchmark; only those signs that were reported by at least 75% of the teachers were considered as 'existing' in PSL. These numbers point to significant lexical gaps affecting teaching and learning in Deaf and Hard-of-Hearing (DHH) students' science education.

Teachers responses validated the textbook analysis with most of them agreeing on the fact that there were no signs for important scientific terms. On the basis of both sources of input, 51 scientific terms were identified with no standardized signs in PSL. They are:

Monera, Protista, Parameciem Spirogyra, Fungi, Yeast, Rhizopus, Monocot, Dicot, Cotyledon, Molluscs, Sponges, Biodiversity, Reptile, Habitat, Decompose, Mumps, Sepal, Carpel, Pedicel, Anther, Filament, Ovule, Stigma, Ovary, Zygote, Embryo, Micropyle, Radicle, Gramseed, Maizseed, Solute, Dissolve, Stirring, Dilute, Combustion, Vapours, Transparent, Disrupt, Luminous, Opaque, Translucent, Particle, Repel, Geologist, Mantle, Core, Texture, Spacecraft, Spying, and Propagation.

The words are major scientific terms, and the lack of their signs poses a serious hindrance to content provision.

Without the presence of PSL signs, teachers listed using three dominant strategies. Fingerspelling was the most frequently used, with words such as Molluscs, Micropyle, Particle, and Spying being frequently spelled out letter by letter. This strategy tended to be cognitively demanding for students, however, particularly for longer or more abstract vocabulary. In most instances, teachers also mentioned skipping the word altogether when no sign was available, especially for challenging words like Pedicel, Texture, Spacecraft, and Luminous. A smaller percentage of teachers mentioned using alternative signs—non-standardized gestures or context borrowed signs—to get across the intended meaning, although these were used irregularly and differed from teacher to teacher.

The list of 51 missing scientific vocabulary provides a critical platform for creation of new PSL signs through consultations with sign language experts, interpreters, and the Deaf community. Filling in these lexical gaps is necessary to facilitate inclusive, equitable, and conceptually rich science education among Deaf students in Pakistan.

Discussion

The research reveals a substantial lexical gap in Pakistan Sign Language (PSL) with respect to scientific terms from the 5th-grade Punjab science textbook. There are 51 terms established to be missing standardized signs, and most of them are pivotal to comprehending major scientific concepts like Monera, Protista, Pedicel, Micropyle, Texture, and Spying. Not only are these reflect themselves signs of the underdevelopment of subject-specific lexis in PSL, but they also place Deaf and Hard-of-Hearing (DHH) learners in a significant educational disadvantage. The lack of standardized signs forces teachers to resort to non-ideal substitutes, such as fingerspelling, skipping words, or improvised gestures, which undermines conceptual accuracy and teaching uniformity.

This trend is consistent with global research indicating that sign languages tend to have inadequate vocabularies in specialist fields like science and technology. Though fingerspelling is a temporary fix, it adds cognitive load and does not facilitate conceptual learning. Skipping important words because there are no signs, as numerous teachers have testified, indicates a serious failure in content access for DHH students. These results highlight the pressing necessity for coordinated and systematic sign construction in PSL, with the participation of teachers, sign language interpreters, and Deaf community members. Enriching the PSL vocabulary with scientific terms standardized across all languages is paramount to

facilitating equal and inclusive science education in Pakistan.

Conclusion

The study highlighted gaps in the 5th-grade Pakistan Sign Language (PSL) science content that are critical, and 51 scientific terms has no standard signs. These lexical gaps act as barriers to effective teaching and restrict access to science for Deaf and Hard-of-Hearing (DHH) students. Teachers are left with less effective approaches like fingerspelling, Skipping the words, or alternative sign, and this affects students' conceptual knowledge. The findings underscore the urgent need for focused development of PSL science-related signs through working in collaboration between teachers, interpreters, and Deaf people for equitable and accessible learning processes.

Recommendations

1. **Development of Standardized Scientific Signs in PSL**

There is a critical need to create standardized signs for the 51 scientific terms identified. The process should involve collaboration between sign language experts, special education teachers, Deaf community members, and linguists to attest to accuracy, cultural sensitivity, and classroom usability.

2. **Integration of New Signs into Teacher Training Programs**

Teacher education programs should update their curricula to incorporate the newly created scientific signs. This will equip existing and future teachers with the tools necessary to provide conceptually strong and diverse science lessons.

3. **Creation of Visual and Digital Resources**

Multimedia materials, including picture sign dictionaries, video lessons, and mobile applications, need to be designed and distributed to schools. The materials will help both teachers and learners in mastering and employing the new PSL lexicon effectively.

4. **Periodic Review and Expansion of PSL Lexicon**

PSL development should be seen as a continuous process. Time to time revision of school textbook should be a focus of stakeholders all subjects and classes to detect more lexical gaps and accordingly increase the lexicon of the sign language.

5. **Policy Advocacy for Inclusive Language Development**

Policymakers need to appreciate the significance of an inclusive PSL and assign funding and institutional resources to designing it. This entails incorporating PSL expansion initiatives into national education policy for enhancing inclusive education.

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