Virtual reality as a solution: Meeting the needs of deaf students with digital sign language interpreters

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Abstract: Sign language is the primary means of communication for people who are deaf or hard of hearing. Sign language interpreters help support deaf individuals in understanding lecture material in class. This study aimed to analyze the need for digital sign language interpreters based on Virtual Reality for deaf students' lectures. This online survey-based study via Google form examined the perceptions and needs of digital sign language interpreters based on virtual reality for deaf student lectures. Participants in this study consisted of 51.5% (male) and 48.5% (female) deaf students from various public and private universities in Indonesia. The results of a survey conducted on 200 deaf students about their interest in using VR showed that 64% (128 students) were in the agreed category. The primary need in lectures for deaf students is a sign language interpreter. The results of a study conducted via the Google form showed that 80% or as many as 160 out of 200 students agreed that they needed sign language interpreters to make it easier for deaf students in the lecture process. The study's results on the perception of the needs of VR and sign language interpreters provide a basis for developing assistive technologies by combining these elements. This will make it easier for deaf students, who are greatly helped by visual media. VR, which can be integrated to display sign language for deaf students, will make explaining the lecturer's lecture material in class easier.
Keywords: Deaf students, Needs analysis, Sign language interpreters, Virtual Reality.

1. Introduction

Ministry of Education and Culture data for 2020 states that out of 4,621 higher education institutions, there are currently 1,588 students with special needs in 28 tertiary institutions, of which 200 are deaf. Quality tertiary education has the challenge of providing accessible educational services for deaf students (Teófilo et al., 2018). Sign language is the primary means of communication for people who are deaf or hard of hearing. Much information is inaccessible to people who are deaf or hard of hearing due to a lack of sign-language interpreters (Fernández-Gavira et al., 2021). A sign language interpreter helps bridge the communication gap between non-deaf peers in the classroom (McDermid, 2020). Deaf students cannot interact with other people without sign language interpreters (Al-Mohimeed et al., 2022) with a sign language interpreter to reduce the isolation of people who are deaf or hard of hearing in society on campus. Sign language interpreters help support deaf individuals in understanding lecture material in class (Ottmar et al., 2015) Understanding the subject matter is necessary for the success of deaf students in lectures. This is to help understand lecture material that is difficult to be exact and to use words that are difficult for deaf students to understand. A sign language interpreter will make it easier for students to ask questions, give opinions, and present at lecture sessions (McDermid, 2020) and more accessible for students to get information on lecture material. The central role of the sign language interpreter is to mediate interactive dialogue between deaf students

and their lecturers and classmates (Raanes & Berge, 2017). Sign language interpreters are an accommodation that deaf students need, but the number of sign language interpreters is minimal (Aljedaani et al., 2023) (Warnicke & Granberg, 2022). Sign language interpreter data obtained by the Sign Language Interpreter Service Center as of 2018-2022 totals 92 people throughout Indonesia (Fernández-Gavira et al., 2021).

The current landscape of sign language interpreting services in higher education institutions reveals significant gaps that impede the accessibility and quality of education for deaf students. One of the most pressing issues is the limited number of qualified sign language interpreters available to support deaf learners in academic settings. This shortage is particularly acute in higher education, where the demand for interpreters often exceeds the supply, leading to inadequate support for students who rely on these services to access course materials and participate fully in classroom activities (Biernacka & Kalata-Zawłocka, 2019)(Schafer et al., 2021). Data from various studies indicate that the number of certified interpreters has not kept pace with the growing enrollment of deaf students in higher education institutions. Many institutions struggle to provide sufficient interpreting services, resulting in significant barriers to communication and learning for deaf students (Hendry et al., 2020) (McDermid, 2020). This lack of interpreters not only affects the academic performance of deaf students but also contributes to feelings of isolation and exclusion within the educational environment (Hendry et al., 2020). Furthermore, existing interpreters often face challenges related to their professional development, which limits their ability to provide high-quality interpreting services that meet the diverse needs of deaf students (Meulder & Haualand, 2019) In summary, the insufficient number of sign language interpreters in higher education institutions underscores a critical gap in the support systems necessary for fostering an inclusive educational environment for deaf students.

The limited number of sign language interpreters cannot serve deaf students daily in university lectures. One of the innovations is using assistive technology to facilitate the sign language needs of deaf students. Technology can make it easier for deaf students to understand the material and be more motivated in lectures (Alshawabkeh et al., 2021). Assistive technology influences the development of communication for people who are deaf or hard of hearing and helps them understand the material in lectures (Alzahrani, 2022). At this time the popular assistive technology used in helping learning problems is Virtual Reality (VR). VR is widely used in various sectors, one of which is education.

The integration of Virtual Reality (VR) into education marks a significant shift towards innovative technologies that enhance learning experiences, particularly for students with disabilities. As a powerful assistive tool, VR creates immersive environments that enable learners to engage with content in ways traditional methods cannot match. Increasing literature supports the effectiveness of VR in various educational contexts, particularly in special education for students with hearing impairments. VR's ability to simulate real-time sign language interpretation provides deaf students with an immersive learning experience, enhancing both comprehension and social interaction (Alsalameen et al., 2023). By interacting with virtual sign language interpreters, students gain a more natural and engaging experience, fostering communication skills while reducing anxiety in a controlled environment (Imran et al., 2021). Numerous studies demonstrate that VR significantly improves learning outcomes by offering experiential learning opportunities that traditional classrooms may lack (Liu et al., 2020)(Natale et al., 2020). A systematic review also found that VR applications boost knowledge retention and engagement, particularly for students with special needs (Hamilton et al., 2020). Additionally, the emotional engagement that VR facilitates is linked to increased motivation and academic performance (Lie, Røykenes, et al., 2023) (Vesisenaho et al., 2019). The safe, risk-free environments created by VR are particularly advantageous for students with disabilities, allowing them to learn at their own pace without fear of judgment or failure (Chimbunde, 2023). In summary, VR is not only a promising assistive technology for deaf students but also a transformative tool that improves learning outcomes across various disabilities. Its immersive, interactive features foster engagement, comprehension, and social interaction, making VR a vital resource in modern education.

VR applications can improve the educational process for children with disabilities and can be a useful tool to support the education of these children (Budi et al., 2021). An important aspect of VR in education is that VR content will enable students to recognize and explore abstract knowledge to be observed in a risk-free environment (Bourhim & Cherkaoui, 2020). Universities engaged in education can utilize VR as a technology to improve the understanding of lecturers' speech in class when there is no sign language interpreter on duty to accompany them (Teófilo et al., 2018). The VR application is an innovative and efficient technology compared to conventional methods of delivering lecture material (Hafit et al., 2019). VR can be recommended to help understand material and communicate in lectures (Kaur et al., 2021). VR is a tool for visualizing real objects to become virtual in 3D which can facilitate and construct the surroundings into a virtual environment.

The potential of Virtual Reality (VR) in higher education, especially for supporting deaf students, is increasingly acknowledged as a transformative tool for enhancing learning experiences. VR can enhance lecture comprehension and facilitate interactive dialogue by simulating real-time sign language interpretation, allowing deaf students to engage more meaningfully with course material. This technology enables students to visualize complex concepts and interact with 3D representations, significantly improving understanding and retention (Young et al., 2020)(Akbulut et al., 2018). Additionally, VR fosters collaborative learning experiences by creating virtual spaces where students can communicate freely, which is particularly beneficial for deaf students who may feel isolated in traditional classroom settings (Hendry et al., 2020). VR's advantages are most apparent when sign language interpreters are unavailable, offering an alternative that incorporates visual aids like sign language avatars, bypassing the need for human interpreters (FİDAN, 2023). The immersive nature of VR also enhances motivation and participation, as research indicates that students find VR environments more stimulating and engaging than conventional classroom settings, leading to better learning outcomes and greater satisfaction (Lactona & Suryanto, 2021)(Akbulut et al., 2018). In summary, VR offers a promising avenue for supporting deaf students in higher education by enhancing comprehension, encouraging participation, and creating a more inclusive learning environment.

Despite the growing adoption of assistive technologies like Virtual Reality (VR) in education, little research has specifically examined its application for sign language interpretation in higher education. Although VR is increasingly used to enhance educational experiences for students with disabilities, its role in providing real-time, immersive sign language interpretation remains underexplored. This gap is significant, given the shortage of qualified interpreters and the rising number of deaf students in higher education. Innovative solutions are urgently needed, and VR presents a promising alternative. However, empirical studies on its implementation and effectiveness for sign language interpretation are still lacking. This research aims to fill that gap by analyzing the potential of VR to facilitate digital sign language interpretation in university lectures, addressing the ongoing challenges deaf students face in accessing quality education.

The virtual learning environment provides a new learning method for students to understand the material provided by the lecturer with the digital sign language interpreter feature, this is possible with VR. This study aimed to analyze the need for digital sign language interpreters based on Virtual Reality for deaf students' lectures.

2. Method

2.1. Research Design

This research adopts a descriptive quantitative approach with a survey type (Mary Havilah Haque et al., 2021). This online survey-based study via Google form examined the perceptions and needs of digital sign language interpreters based on virtual reality for deaf student lectures. This study was initiated by a research team from the Center for Disability Studies at Sebelas Maret University in Surakarta, Indonesia. To recruit participants, WhatsApp messages were used to the deaf student association group in Indonesia to provide information on filling out the questionnaire, which was

distributed via the Google form link in early August 2023. This survey was open to completion until the end of August 2023 at campuses with deaf students throughout Indonesia.

2.2. Participants

In 2020, the Ministry of Education and Culture stated that out of 4,621 higher education institutions, there are currently 1,588 students with special needs in 28 tertiary institutions, of which 200 are deaf. Participants in this study consisted of 51.5% (male) and 48.5% (female) deaf students from various public and private universities in Indonesia (Sugiyono, 2018). Most deaf students have entered college for the past two years, so they have an idea of difficulty understanding course material if there is no JBI. This requires new innovations, namely the development of digital sign language interpreters based on virtual reality for deaf students in college.

Table 1.
Demographics of deaf students in Indonesia.

No	University	Total
1	Kartini's Social Welfare Academy	2
2	Kupang Social Work Academy	2
3	Bandung Culinary Academy	3
4	Telkom Purwokerto Institute of Technology	5
5	Indonesian College of Informatics & Computers	4
6	STMIK Pringsewu	2
7	Airlangga University	6
8	Yogyakarta Atma Jaya University	4
9	Surabaya Ciputra University	2
10	Universitas Dhyana Pura	1
11	Universitas Indonesia	4
12	Universitas Islam Nusantara	2
13	Universitas Jayabaya	1
14	Universitas Katolik Indonesia Atma Jaya	2
15	Universitas Kristen Maranatha	1
16	Universitas Lambung Mangkurat	8
17	State University of Jakarta	25
18	State University of Makassar	4
19	State University of Malang	15
20	State University of Semarang	2
21	State University of Surabaya	20
22	State University of Yogyakarta	25
23	Universitas Padjadjaran	2
24	Universitas Pamulang	4
25	Universitas Pendidikan Indonesia	15
26	Universitas Sultan Ageng Tirtayasa	8
27	Universitas Trisakti	2
28	Universitas Sebelas Maret	29
	Total	200

Table 2.
Demographic information about the participants.

		Gender	
	N	**Female**	**Male**
Total	200	97	103
%		48,5	51,5

2.3. Data Collection Tools and Data Analysis

The survey instrument is used to examine the perceptions and needs of digital sign language interpreters based on virtual reality for deaf student lectures (Arikunto, 2010). The device consists of two parts: the instrument regarding Virtual Reality (VR) conditions and the Sign Language Interpreter. The answer choices are divided into 4 Likert scales, namely 4: Strongly Agree, 3: Agree, 2: Disagree, and 1: Do not agree, considering that deaf students easily understand these choices. The instrument has been validated by 25 experts from special education, psychology, and educational evaluation (Silalahi, 2015). Quantitative data were analyzed using descriptive statistics, which included mean, standard deviation, and frequency.

3. Results

The results of filling in the instrument to examine the perceptions and needs of digital sign language interpreters based on virtual reality for deaf student lectures. The instrument consists of two parts: the instrument regarding Virtual Reality (VR) needs and the Sign Language Interpreter. The results of the study show that the five aspects asked of deaf students in the instrument show that the average agrees to use VR, and the need for sign language interpreters for deaf students is very much needed in their studies, more clearly as can be seen in Tables 3 and 4.

Table 3.
The need for using VR in lectures for deaf students.

No	Aspect	Strongly agree	Agree	Disagree	Do not agree
1	I understand the VR example	29.80%	51.10%	17%	2.10%
2	I'm interested in using VR	17%	63.80%	12.80%	6.40%
3	I love using VR	19.10%	44.70%	25.50%	10.60%
4	I need visual media like VR	23.40%	51.10%	19.10%	6.40%
5	VR media helps me in lectures	29.80%	57.40%	6.40%	6.40%

Table 4.
The need for sign language interpreters in lectures for deaf students.

Aspect	Strongly agree	Agree	Disagree	Do not agree
I need a sign language interpreter for college	57.40%	27.70%	12.80%	2.10%
Sign language interpreters help me communicate in class	48.90%	36.20%	6.40%	8.50%
The Sign Language Interpreter helped me access the course material	46.80%	38.30%	8.50%	6.40%

The results highlight both the strong interest in using Virtual Reality (VR) and the critical need for sign language interpreters in lectures for deaf students. From the data, 80.9% of students indicated they understood VR examples, and 80.8% showed interest in using VR. Additionally, 74.5% expressed a need for visual media like VR, with 87.2% agreeing that VR helps them in lectures, suggesting its potential as an effective learning tool. Simultaneously, the majority of students, 85.1%, emphasized the importance

of sign language interpreters, with 85.1% agreeing that interpreters aid communication and access to course materials. These findings underscore the complementary roles of both VR and sign language interpreters in creating an accessible and engaging learning environment for deaf students.

The results of a survey conducted on 200 deaf students about their interest in using VR showed that 64% (128 students) were in the agreed category. This shows that deaf students are interested in using VR technology in lectures.
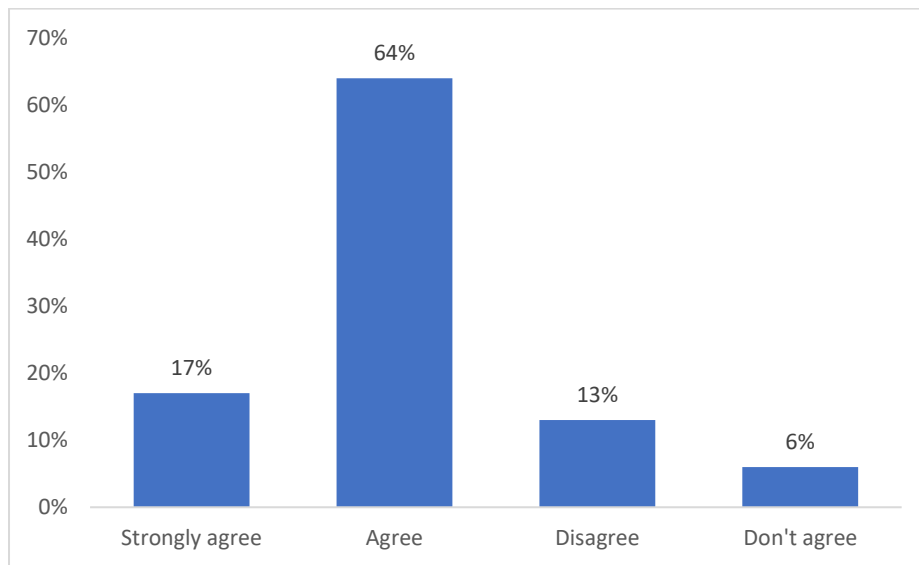
Figure 1.
Percentage of student interest in using VR.

Previous studies have shown that deaf students are very interested in using VR in lectures. This impacts students' perceptions of the development of VR media as an assistive technology that can help deaf students understand lecture material delivered by lecturers. The results of the study show that 57% (114 students) have the agreed category and 30% (60 students) have the strongly agree category which can be seen in Figure 2, below:
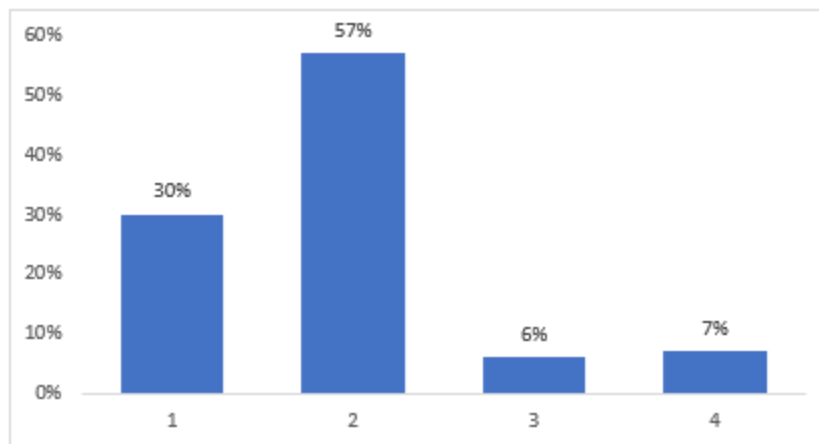

Figure 2.
Percentage of perceptions of VR media to help deaf students in lectures.

The basic need in lectures for deaf students is a sign language interpreter. The results of a study conducted via the Google form showed that 80% or as many as 160 out of 200 students agreed that they needed sign language interpreters to make it easier for deaf students in the lecture process. The lecture process is where the lecturer sometimes provides lecture material with words that are difficult to understand and foreign vocabulary related to the science of the deaf student study program.

The study's findings on the perceived need for both VR and sign language interpreters offer a valuable foundation for advancing assistive technologies by integrating these two elements. This combination will greatly enhance the learning experience for deaf students, who benefit significantly from visual media. By utilizing VR to deliver sign language interpretation, educators can more effectively communicate lecture content, creating a more accessible and engaging classroom environment for deaf students.

4. Discussion

Virtual Reality (VR) technology is widely utilized for learning media, practical training, and assessment, including evaluating hearing levels in individuals who are deaf or hard of hearing (Salanger et al., 2020). Deaf students have unique educational needs, particularly in lecture settings where communication is critical for comprehension and engagement. Effective sign language interpretation is essential for enabling deaf students to understand lecture content and participate in discussions. However, limitations in the availability, skill level, and consistency of human interpreters can impede the learning process, leading to delays and potential miscommunication (Biernacka & Kalata-Zawłocka, 2019). Virtual Reality (VR) offers a promising alternative by providing real-time sign language interpretation through avatars or virtual interpreters, ensuring consistent and accurate translation of spoken content (Gar & Idris, 2021). This technology creates an immersive learning environment that enhances comprehension and retention by presenting material in a visually engaging context. Moreover, VR facilitates interactive dialogue, enabling dynamic communication between deaf students, peers, and instructors, surpassing the constraints of traditional classrooms. By integrating VR, educational institutions can address the shortage of qualified interpreters and foster a more inclusive and engaging learning experience, ultimately promoting greater academic success and social integration for deaf students.

Deaf people use VR applications to train themselves to recognize the sound of musical instruments; with VR, deaf individuals understand the intonation of sound vibrations emitted by musical instruments (Rayes et al., 2019). Another use of VR for hearing-impaired voice recognition accessibility is the development of EarVR to help analyze sound and inform users about the direction of sound (Mirzaei et al., 2020). VR can also be used in learning games that can attract the attention of deaf individuals to understand learning materials such as science, social studies, and mathematics (Syed et al., 2019). VR helps people who are deaf or hard of hearing learn mathematics with sign language, translating abstract mathematical material (Southgate et al., 2019). Ghoul and Othman's research utilizes VR for sign language training for teachers and parents in America, where VR displays 3D avatars acting as tutors providing sign language basics (Ghoul & Othman, 2022).

Virtual reality (VR) technology holds significant potential in addressing the unique needs of deaf students in educational settings. Through immersive environments and holographic avatars, VR can enhance sign language learning (Kasapakis et al., 2023)(Yang et al., 2022). Devices like EarVR, which provide haptic feedback, further improve accessibility for deaf users (Mirzaei et al., 2020). While VR has been explored for students with disabilities, particularly in K-12 settings, most research employs non-immersive simulations (Carreon et al., 2020). However, VR-based experiential learning has shown promise for language acquisition and communication skill development in higher education (Rho et al., 2020)(McGovern et al., 2020). Its immersive features can deepen understanding of course content and future work environments (Tham et al., 2018). Moreover, Universal Design for Learning principles can enhance online education for deaf students, addressing accessibility issues in distance learning (Taylor & Yuknis, 2023).

Despite its potential, several barriers hinder the effective integration of VR in deaf education. The high cost of VR equipment and software, along with the need for specialized technical support, poses challenges for many institutions (Guruloo, 2023)(Ravichandran & Mahapatra, 2023). Additionally, educators often lack the necessary training to implement VR tools effectively, compounded by limited understanding of the unique needs of deaf students (Hendry et al., 2020). Issues like motion sickness and discomfort further complicate VR adoption (Lie, Helle, et al., 2023). Finally, the rapid shift to online and hybrid learning during the COVID-19 pandemic exposed infrastructural gaps in supporting VR for diverse learners, highlighting the need for enhanced resources and training (Alsadoon & Turkestani, 2020). Overcoming these obstacles is crucial to unlocking VR's transformative potential for deaf education.

VR plays an essential role in the teaching process, understanding abstract material and providing an exciting way to obtain information (Kamińska et al., 2019). The visuals displayed by VR provide a fun learning atmosphere and motivate students to understand the material (Khukalenko et al., 2022). A real-time sign language interpretation system enables communication for deaf and hard-of-hearing individuals (Papatsimouli et al., 2023). The lack of a sense of hearing in deaf people causes their cognitive and intellectual skills to be low due to the inability of deaf students to understand lecture material without aids and sign language interpreters. The novelty value of this research from previous research is that there is no use of VR to help deaf students get sign language services digitally through VR.

Feedback from deaf students is crucial in evaluating the effectiveness of VR-based sign language interpreters. This feedback can provide insights into how well VR meets their communication needs in the context of lectures, as well as whether the technology can enhance their comprehension of course material. Research findings indicate that the use of VR media is highly beneficial for deaf students, as this technology can overcome the limitations of human interpreters and provide more consistent and interactive access to lecture content. By gathering perspectives from deaf students, technology developers can improve aspects that may still be lacking, such as delays in interpretation or difficulties in system navigation. Furthermore, this feedback can also aid in understanding overall user comfort and experience, which will ultimately contribute to the development of more intuitive and user-friendly VR systems. Positive acceptance and response from users will be key in ensuring that this VR technology can be effectively integrated into the learning process for deaf students in higher education institutions.

5. Conclusion

Sign language is the main means of communication for people who are deaf or hard of hearing. Sign language interpreters help support deaf individuals in understanding lecture material in class. This study aimed to analyze the need for digital sign language interpreters based on Virtual Reality for deaf students' lectures. The results of a survey conducted on 200 deaf students about their interest in using VR showed that 64% (128 students) were in the agreed category. The primary need in lectures for deaf students is a sign language interpreter. The results of a study conducted via the Google form showed that 80% or as many as 160 out of 200 students agreed that they needed sign language interpreters to make it easier for deaf students in the lecture process. The study's results on the perception of the needs of VR and sign language interpreters provide a basis for developing assistive technologies by combining these elements. This will make it easier for deaf students who are greatly helped by visual media. VR, which can be integrated to display sign language for deaf students will make it easier to explain lecturer's lecture material in class.

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