From Theory to Practice: Implementing Artificial Intelligence in Sign Language Instruction in Cameroon

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ABSTRACT

This study chronicles our efforts in exploring challenges faced in traditional sign language teaching methods and proposes AI- driven solutions that effectively address these issues. We place this study in the framework of Technology Acceptance Model (TAM). This experimental study was carried out with 40 undergraduate university students in Bambili - North West Region of Cameroon. An experimental research design was employed involving real-time training using Neural Network (DenseNet 201 Model) online tool. Observation sessions and 40 questionnaires were used as instruments for data collection. Findings indicate that: 1.Traditional teaching methods characterized: Passive learning, heavy reliance on the teacher as the sole source of knowledge, inadequate opportunities for practical applications, rote memorization and repetition of gestures hindered smooth teaching and learning.2.The use of AI- driven tools: Video demonstrations for sign recognition included datasets of 100 images,26 letters of manual alphabets, 30 numbers, 50 fingerspelled words, 40 common phrases and 25 basic signs, capturing handshapes and gestures, angles, positions, and proximity enhanced students learning skills. By adopting these modern teaching methods with AI tools, teachers create a learning environment that promotes active engagement, practical application and effective communication skills in sign language. The study recommends that Governments, educational institutions, and organizations should promote sign language and challenge negative stereotypes by encouraging innovative technologies that foster the teaching and learning of sign language.

Keywords: Sign language teaching, traditional methods, innovative approaches, artificial intelligence, personalized instruction, machine learning algorithms, recognition systems.

INTRODUCTION AND PROBLEM

Traditional sign language teaching methods have been used for many years to help students learn and communicate in sign language. These methods typically involved in-person instruction, visual demonstrations and practice sessions. These methods hindered the smooth and fast acquisition of the language. As technology continues to advance, there is a growing need for innovation in sign language instruction to enhance the learning experience and meet diverse needs of learners. As regard In-person instruction, the method involved a sign language teacher teaching students face to face through sign demonstration, while explaining their meanings to students. In visual demonstration teachers use their hands and body movements to show the signs, allowing the students only to observe and imitate the gestures. In these methods sign language teaching focuses on building strong vocabulary. Students learn a variety of signs for different words and concepts, gradually expanding their knowledge and understanding of the language. In addition to vocabulary, teaching also covers grammar and syntax. Students learn the rules and structure of sign language sentences, including word order, facial expressions, and body movements. While these traditional methods are valuable, they may not be accessible and convenient for all learners. This is where apps and software programs come in, offering interactive and engaging platforms that leverage technology to make sign language learning more accessible and enjoyable. AI technology can enhance the learning experience by providing additional resources and support. With the advancements in AI technology, innovative approaches that combine traditional teaching methods with AI enhanced students learning skills. AI systems can analyze and recognize gestures, allowing students to identify and correct their errors. AI powered platforms provides interactive learning experiences through the use of virtual reality or augmented reality technologies. Students engage in realistic stimulations, immersive environments and exercises

that facilitate application of sign language skills. AI systems analyse students signing gestures, providing immediate feedback that helps students correct errors leading to faster skill development and improvement. AI –powered platforms enable remote learning and accessibility. Students can access sign language instruction from anywhere.

Nevertheless, the role of the teacher in providing guidance, support, and meaningful interactions is irreplaceable. AI should be used as a tool to support and augment the teaching process. It is not a substitute for human expertise. In our pursuit of this noble goal, we embarked on the study with the following objectives.

Research Objectives

The study has the following objectives:

- To identify challenges faced in traditional sign language teaching methods
- To explore innovative approaches in utilizing Artificial Intelligence to enhance sign language teaching

These objectives led to the following research questions.

Research Questions

The following research questions served as guidelines to the study:

RQ1: What are the challenges faced by students in traditional methods of sign language teaching

RQ2: Which innovative approaches are employed to enhance sign language teaching

Pedagogic relevance

The integration of AI in sign language instruction offers numerous pedagogic benefits including: personalized learning, accessibility and availability, eradicating barriers and independent access to information. AI does not replace teachers but rather augment their expertise. Teachers' role is crucial in guiding and supporting students learning. Through the use of VR and AR technologies, students engage in realistic simulations. This hands- on approach fosters learning retention and builds confidence in fluency in sign communication. The study of sign language and artificial intelligence holds significant importance for several reasons:

Personalized Learning

AI adapts to the individual learning needs of each student. It analyses their progress, identifies areas of improvement, and provide feedback. This approach enhances effective teaching and looks into unique needs and learning styles of students.

Accessibility and Availability

Online applications provide access to sign language lessons, allowing students to learn at their own pace and convenience. AI-based sign language teaching is made available and accessible to many students especially those with android gadgets.

Eradicating barriers

AI technology overcomes some limitations of traditional sign language teaching. AI captures facial expressions and movements which are important aspects in sign language communication. This favours a more comprehensive and accurate representation of signs.

Independent access to information

AI-generated signs empower students to independently access information. This reduces their reliance on written materials, allowing them to have direct access to sign language videos.

REVIEW OF RELATED LITERATURE

Literature review consists of conceptual, theoretical and empirical framework within which the present study was carried out. The conceptual frame examined concepts that are related to the research topic. The theoretical frame focused on Technology Acceptance Model (TAM) applied to support the research in practical settings. The empirical frame reviewed previous practical research studies on similar topics.

Conceptual framework

Concepts used in this study include: Sign language teaching and artificial intelligence

The teaching of sign language

Teaching sign language is an endeavour that plays a significant role in promoting communication and inclusivity for hard of hearing individuals. Effective teaching requires a thoughtful approach that is rooted in understanding the unique needs and challenges of students.

Teaching sign language requires prioritizing the development of a strong foundation in vocabulary and grammar. This involves introducing students to a wide range of signs and teaching them the rules and the structure of the language.

Teachers should focus on creating supportive learning environments. This can be achieved through interactive activities, role play exercises that stimulate the practical use of sign language. For effective acquisition, teachers should encourage regular practice.

Teaching students to understand and interpret facial expressions, body language, and other visual cues that contribute to the overall meaning and context of signed messages are integral to sign language teaching.

As technology continues to advance, integrating digital tools and resources into sign language teaching can enhance enormously the learning experience of students. Online learning platform provide additional opportunities for practice, self-paced learning and feedback. These tools supplement traditional teaching methods and create a more engaging learning environment.

It is vital for teachers to attend workshops, conferences, and professional development programs in order to refine their teaching techniques, learn new strategies, and stay connected the broader sign language community.

In all, effective sign language instruction requires a comprehensive and holistic approach that encompasses vocabulary, grammar, non-verbal communication and the integration of technology. Employing these strategies teachers can empower students with the skills and confidence to effectively communicate in sign language and foster amore inclusive society for deaf individuals.

The role of AI in sign language instruction

The significance of artificial intelligence (AI) in the realm of sign language teaching cannot be overemphasized. As technology advances at an unprecedented pace, AI has emerged as a powerful tool for enhancing the teaching and learning experience for deaf and hearing individuals.

Traditionally, sign language teaching relied solely on human instructors who possess expertise in sign language and pedagogy. While this approach has been effective to some extent, it is often limited by factors such as availability of qualified teachers, geographical constraints, and the high cost associated with personalized teaching.

Leveraging algorithms and computer vision techniques, AI can analyze and interpret sign language gestures with remarkable accuracy. This opens up new possibilities for providing guidance to learners even in the absence of a teacher.

One key advantage of using AI in sign language teaching is its ability to adapt to the unique learning needs of students. Through the use of algorithms, AI systems can access the proficiency level of students and tailor teaching accordingly. It ensures students receive feedback and instruction, leading to faster and more effective learning outcomes.

Theoretical framework

We place this study in the framework of Technology Acceptance Model (TAM). The TAM framework postulated by Mark Snyder (2000) explores factors that influence the acceptance and adoption of technology. In the context of this study, TAM helps identify the factors that affect the acceptance and utilization of AI-driven tools and systems in sign language teaching. Variables such as perceived usefulness, ease of use, and attitudes towards technology are examined to understand the adoption of AI in sign language education. By integrating this theoretical perspective, the study provides a comprehensive understanding of the implications, challenges, and opportunities associated with the integration of artificial intelligence into sign language teaching. This theoretical framework guides the analysis and interpretation of empirical data, allowing for deeper exploration of the research objectives.

The Technology Acceptance Model (TAM) is a system that models how users come to accept and use a technology. The model suggests that when users are presented with a new technology, a number of factors influence their decision about how and when they will use it, notably:

Perceived Usefulness (PU)

Defined by Fred Davis as "the degree to which a person believes that, using a particular system would enhance their job performance". This means whether or not someone perceives that technology will be useful for what they intend to do.

Perceived Ease of Use (PEOU)

Davis defines this as "the degree to which a person believes that using a particular system would be free from effort. If the technology is easy to use, then the barrier is conquered. If it is not easy to use and the interface is complicated no one has a positive attitude towards it.

An external variable such as social influence is an important factor to determine the attitude. When TAM is in place students will have the attitude and intention to use the technology.

Empirical framework

Studies have explored challenges facing sign language education, such as shortage of qualified instructors and lack of personalized instruction. Researchers have emphasized the importance of sign language education in fostering inclusivity and accessible communication for hard of hearing community (Mavris et al., 2020, Wolbers et al., 2018).

The potential impact of employment opportunities for sign language instructors has been a topic of discussion (Brynjolfsson and McAfee,2014, Frey and Osbone, 2017).

Literature also discusses the potential of AI-powered sign language recognition systems in bridging communication gap between sign language users and non-sign language users (Koutsombogera& Papageorgiou, 2018, Shi et al., 2019). These systems can accurately interpret and translate sign language, facilitating greater inclusivity and understanding in various contexts such as education and social interactions.

Bendarkar et al. (2001) carried out a study on ASL recognition using Convolutional Neural Network (CNN). The study incorporated pre-trained 16 signs for static gesture recognition. Accuracy was tested against hand gestures for ASL letters captured webcam images was determined at 90%.

Kumar, (2002) looked into challenges in recognizing British Sign Language fingerspelling alphabet using Deep

Neural Network. The study improved upon traditional methods by achieving recall, and F-measure percentages for broad lexicon of words. The study reported an accuracy rate of 98.0%.

Research gap

In Cameroon, a recognizable gap is realized in existing literature on sign language recognition web-based applications. Most research focus on specialized settings, leaving online integration applications unexplored. This research endeavour is, the cornerstone of this work as it addresses critical need for innovative teaching approaches into sign language teaching and training. In recent years more innovative web tools have been established for language teaching and learning. The challenge therefore is for teachers to develop their expertise in integrating these new tools into effective teaching environments. This article provides a platform for sign language teachers and researchers to share their experiences in sign language teaching strategies, pedagogy and technology with other teachers around the world.

METHODOLOGY

Various materials and methods used in collecting, managing, analyzing and interpreting data throughout the study are discussed. These include the research population, sample and sampling technique, instruments, design, procedure for data collection, and method of analyzing data.

Population of the Study

The population of the study was made up of 40 undergraduate hearing students in the University of Bamenda offering sign language as a course in their academic program. The reason for this sample is because these students are actively involved in the teaching and learning process of sign language as a compulsory course for the semester. The table below presents population of students.

Table 1: Population of students

No	Name of Institution	Number of students
1	The University of Bamenda	40

Table 1 indicates that there are 40 students studying sign language in the University of bamenda. The reason for this sample is because the researcher intended to work with particular students who will provide qualitative and reliable information on the topic under study and sample could be easily managed.

Demographic information on the sample

The sample of the study was made up of both male and female students. Female students formed the majority of the sample as seen on the table that follows.

Table 2: The sex of the students

Sex	Frequency	Percentage
Male	6	15
Female	34	85

Table 2 indicates that out of 40 students who made up the sample 6(15%) were males and 34(85%) were females.

Report of questionnaires return and presentation

All the questionnaires administered to students were duly answered and returned to the researcher. Table 3 shows

the report of the returns.

Table 3: Report of questionnaires administered and returned

Questionnaires / Institution	Number of questionnaires distributed	Number of questionnaires returned	Percentage returned %
The University of Bamenda	40	40	100

Table 3 reveals that 40 questionnaires were distributed to students; all were answered and returned to the researcher giving a percentage return of 100%.

Sampling Technique

This study employed the stratified sampling technique due to the diverse nature of students in relation to characteristics such as demographic factors, socio-economic status, and geographic location. Stratified sampling is beneficial in terms of accuracy and representativeness which makes it a valuable research technique.

Research instruments

Classroom observation checklist and questionnaires were the main instruments used in this study. The research instruments were constructed taking into account the objectives and research questions which were broken down into sub questions to build the questionnaire.

The Questionnaire was used to obtain quantitative data and contained items geared towards obtaining information on difficulties teachers encounter in the classroom. Some of the questions were open ended while others close ended.

An observation checklist was established. The observation was carried out in the classroom context. This enabled the researcher to naturally witness what was going on practically in the classroom. Observations of practical classroom signing exercises were used to check students' acquisition and signing skills. The questionnaires were personally administered by the researcher through the direct delivery method.

Method of Data Collection

Datasets of 271 images were created in order to monitor students' performances during training. They consisted of video demonstrations for sign recognition consisting 100 images, 26 letters of manual alphabets, 30 numbers, 50 fingerspelled words, 40 common phrases and 25 basic signs, capturing handshapes and gestures, angles, positions, and proximity. Students were trained using online tool (DenseNet 201 Model). They had a validation accuracy of 85% as well as good performance metric during lessons. We decided to use DensNet201 model because this design does not demand computational efficiency. This online tool can be used from a computer or mobile phone.

Data collection procedure

The first step in AI sign language training was collection of large datasets of sign language videos*:* These videos were annotated to label the different signs and gestures present in the videos.

The second step was processing and feature extraction: The collected sign language videos were preprocessed and extraction of relevant features from the videos: hand movements, facial expressions, and body postures was done.

The third step was learning models and real-time recognition: Students were trained using neural networks and

annotated datasets. These students learned how to recognize and classify different signs and gestures based on the extracted features.

The last step was feedback and correction: Feedback mechanisms provided students with feedback on their signing accuracy. Feedback helped students in improving their signing skills and correcting their errors.

Data analysis technique

The researcher used computer vision and data visualization to analyze and interpret data through sign recognition, translation and linguistic analysis. Computer vision algorithms were employed to analyzevideo recordings of signs while detecting hand movements, facial expressions and other visual cues. These algorithms were used to extract features and patterns, enabling students to study the structure and grammar of sign language.

FINDINGS

Results of this study are organized in accordance with the research objectives and questions.

Traditional teaching method

RQ1: What challenges did students face in traditional methods of sign language teaching

Findings reveal that during the initial stage of training using traditional methods in teaching sign language, students encountered two major challenges:

Lack of visual resources

During the initial stage of training, traditional teaching method was employed in the classroom. This method relied heavily on verbal explanations thereby, leaving students with limited visual guidance. The absence of visual resources such as videos and multimedia presentations made it difficult for students to grasp the nuances of sign language and understand the visual grammar that underlies it.

Solution

Integrating visual resources later in the classroom greatly enhanced students learning experiences. Utilizing video demonstrations and interactive online platforms helped students better comprehend concepts and improved their overall signing proficiencies.

Inadequate interactions

Limited interactions in traditional sign language lessons impeded students' progress and hindered their signing skills. Heavy reliance on the teacher as the sole source of knowledge resulted in limited interactions. This led to passive learning environment where students became less engaged and less empowered.

Solution

Incorporating interactive activities such as group exercises, role-playing scenarios, and conversational practice sessions provided students with ample opportunities to apply and build their signing skills.

Recognizing and addressing difficulties faced by students during traditional method of teaching and learning sign language was crucial in order to create a more effective learning environment. Incorporating interactive activities and visual resources students were empowered and achieved greater proficiency.

Innovative approaches

RQ2: Which innovative approaches employed improved sign language teaching

During the second phase of training the researcher turned to innovative approaches that promoted engagement,

retention, and fluency to enhance effective teaching and learning of sign language. Innovative approaches employed during lessons included:

Technology integration

Integrating technology into sign language lessons significantly enhanced students learning experience. Video tutorials, interactive apps, and online platforms provided learners with accessible and engaging resources. These tools offered visual demonstrations, interactive exercises and immediate feedback, which enabled students to practice and refine their skills. The teacher combined technology with visual, auditory, and kinesthetic techniques to engage students. The teacher used the following videos below as preferences to maximize students learning outcomes.

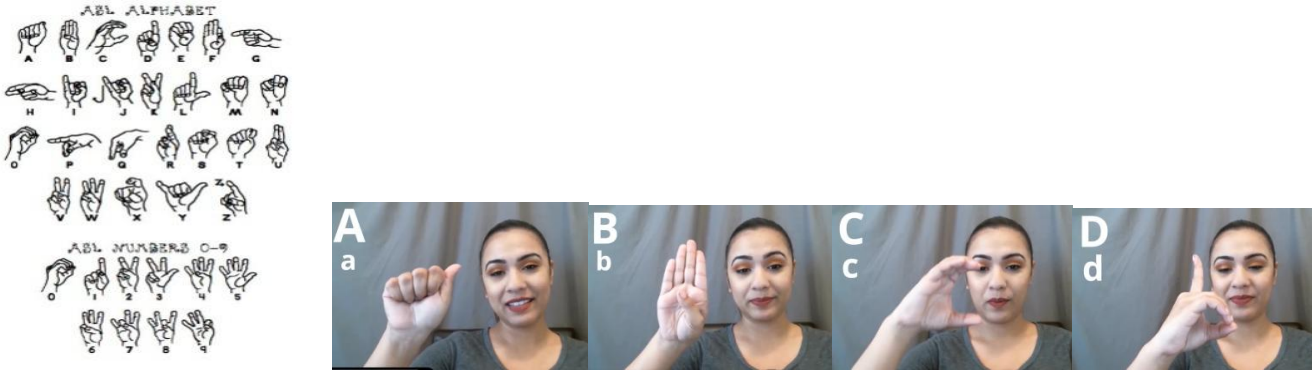

Fig 1: The 26 Manual Alphabets From A-Z

Taking lessons on how to sign manual alphabets. These are tips that will help you master the letters A-Z. Let's get started.

Fig 2: Signing Numbers From 1-30

Knowing how to sign numbers will help you know how to sign things like dates, time, prices and age.

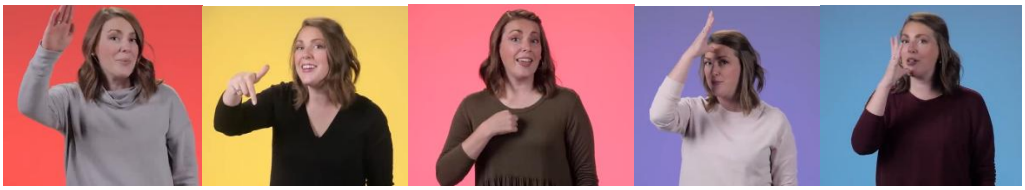

Fig 3: 25 Basic Signs You Need to Know

Before you begin, you need to know that there are five important things. The handshape, palm orientation, hand movement, location and non-manual signals.

Fig 4: 40 Common Phrases

We begin learning the most basic and common phrases. You need to know the most popular signs such as: I love you, what is your name, nice to meet you, are you deaf or hearing etc.

Fig 5: 50 Fingerspelled Words

We use fingerspelling to sign names, books, movies and more. There are important do's and dont's. Find out more.

Fig 6: 100 signs

When signing words do not wave your hand from your body. Keep hands close towards you and then read the word as one sign.

CONCLUSION

The employment of innovative approaches in sign language lessons has revolutionized the learning experience of students. Leveraging AI technology, the teacher created engaging, effective, and inclusive learning environment. This approach not only enhanced fluency, it empowered students to communicate confidently and effectively.

In conclusion the study has shed light on the immense potential of technology to revolutionalise sign language teaching. Videos highlighted the advancements in learning techniques, enabling more accurate reliable recognition and interpretation of gestures. While moving forward, continued research and development, coupled with commitment to inclusivity are paramount.

By harnessing the potential of AI-powered sign language recognition systems, we strive towards a more inclusive and accessible society, where communication barriers are diminished and hard of hearing community can fully participate and thrive in various aspects of life.

RECOMMENDATIONS

Based on the research findings, several recommendations are made to further advance AI-powered sign language recognition systems:

1. Develop training programs and educational resources for professionals working with AI-powered sign language recognition systems. This will ensure that they have the necessary skills and knowledge to effectively implement these technologies in education.
2. Foster international collaborations and knowledge sharing among researchers, teachers, and organizations working in the field of AI-powered recognition systems. This will facilitate exchange of ideas, best practices, and lessons earned, leading to accelerated advancement and the development of standardized approaches.
3. Researchers should continue to invest in the development of AI algorithms and deep learning techniques to improve the accuracy of sign language recognition systems. This includes addressing

individual signing styles, and expanding the vocabulary and complexity of sign language gestures.

TRAJECTORIES

Trajectories of AI-powered sign language recognition systems is marked by technological advancements, increase integration, and enhanced user experience.

Technological advancements

The trajectory of AI-powered sign language recognition system is driven by continuous technological advancements. Researchers are pushing boundaries of learning algorithms , computer vision techniques, and natural language processing to improve the accuracy , speed, and versatility of these systems. As technology continues to evolve, we expect to use more sophisticated and effective sign language systems.

Increasing integration

As awareness and understanding of the benefits of these systems grow, education, work places, public services, are recognizing their potential. This increased integration will contribute to the normalization of these technologies.

Enhanced user experience

The trajectory of AI-powered sign language systems is focused on enhancing the user experience. Designs which are user centered are being used to ensure that systems are intuitive, accessible and customizable to meet the needs of users.

By continuing to innovate, we propel these systems further along their trajectory, creating a more inclusive and accessible society for both deaf and hearing communities. We can expect further innovations in this field, expanding the range of options available for sign language learners.

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