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Empowering Communication for Students with Speech Impairments: Designing an Assistive Technology Framework for Enhanced Educational Engagement

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Abstract: This research investigates the design of an assistive technology framework to facilitate increased educational participation and communication among students with speech impairments based on the field of Human-Computer Interaction (HCI). Overcoming current hindrances such as limited accessibility, exorbitant costs, and lack of adequate teacher training, the study incorporates sophisticated tools such as AI-powered speech recognition, text-to-speech, speech-generating devices, and augmented reality. The design prioritizes usability, accessibility, and personalization while ensuring alignment with principles of Universal Design for Learning (UDL). Quantitatively, the research shows that the proposed system enhances communication skills and active participation in learning substantially. Results underscore the importance of inclusive design, collaboration with stakeholders, and continued technological innovation to create equal opportunities for education among speech-impaired students.

Keywords*: S.*

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I. INTRODUCTION

A. Background and Context

Human-Computer Interaction (HCI) is a major element in assistive technology design aimed at increasing communication for students who are speech-impaired. HCI focuses on designing user-oriented products that bridge the gap between technology and human requirements, ensuring usability and accessibility. In the field of education, HCI ideas guide the design of speech-generating devices, text-to-speech software, and AI-based communication tools. These technologies not only enhance interaction but also inclusivity as they enable students with speech impairments to be able to participate in learning activities fully in classrooms and interact well with other students and teachers.

There are still challenges even with innovation in assistive technology to integrate these devices within schools. Inadequate resources, inadequate training of teachers, and inadequate tailored solutions often hinder the seamless integration of assistive technologies. Furthermore, systemic issues such as resource-deprived schools and insufficient coordination between specialists and educators exacerbate the problems. As a result, the majority of children who have speech disability continue to face communication and participation barriers, impacting their school performance and social integration.

In conclusion, facilitating communication for students with speech disabilities requires an integrated system that brings together innovative assistive technologies and flexible support mechanisms. By applying HCI principles, resolving current challenges, and encouraging interaction among stakeholders, teachers can create accessible environments that facilitate learning participation for all students. This solution not only improves the learning experience of students with speech disabilities but also enhances the learning environment by increasing diversity and accessibility.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25may562

B. Research Problem

Despite their potential, assistive technology use in schools is typically limited by issues with expenses, availability, and non-modulated support for a variety of speech difficulties. The research targets the development of an assistive technology platform through which various modalities would aid the communication and pedagogical empowerment of students with speech disabilities.

C. Research Questions and Objectives

- How can assistive technologies improve communication and educational outcomes for students with speech impairments?
- What strategies can ensure equitable access to these technologies across diverse educational settings?
- How can educators effectively integrate assistive technologies into their teaching practices to support students with speech impairments?

D. Objectives

- Develop an assistive technology framework integrating speech recognition, text-to-speech systems, and AR to support diverse communication needs.
- Evaluate the impact of the framework on student engagement, communication skills, and academic performance through pilot studies.
- Identify best practices for integrating assistive technologies into educational curricula while ensuring equity and accessibility.

E. Justification and Significance

This research highlights the inclusive design models in catering for diverse learners by drawing from theory such as the Universal Design for Learning (UDL) concept. The goal is to enhance the educational equality and communication opportunity for speech-disabled students through overcoming the limitations within the current utilization of assistive technology, thus facilitating increased engagement of society.

II. LITERATURE REVIEW

A. Overview of Assistive Technologies

Assistive technologies (AT) for communication have dramatically changed, evolving from simple mechanical devices to advanced digital systems that greatly improve the communication abilities of people with various needs. The contemporary AT landscape encompasses a broad range of tools, including advanced speech recognition software, text-to-speech systems, and new augmented reality (AR) interfaces, all carefully crafted to enhance communication for people with different challenges (Lancioni et al., 2019). This article gives an in-depth analysis of these technologies, tracing their historical development, examining their contemporary applications, and analyzing the theoretical frameworks that underlie their design and implementation. The research employs a Descriptive Design methodology to measure systematically the usability, accessibility, and general capability of these systems.

B. Historical Development of Assistive Technologies

The evolution of assistive technology in history is an interesting chronology that started with ancient cultures, where straightforward aids such as canes were used to provide mobility support and simple devices such as ear trumpets were used to correct impairments in hearing (Fuller, 2018). The turning point in the evolution of AT was reached in 1824 when Louis Braille developed the Braille system, a tactile script that transformed communication and education for visually impaired people (Koenig & Holbrook, 2000). The 20th century saw tremendous technological advancements, with the first electric hearing aids being introduced, followed by the innovation of more miniaturized and power-efficient transistor-based hearing aids in the 1950s (Martin, 2014).

The latter half of the 20th century witnessed the dawn of computer technology, which unveiled hitherto unprecedented opportunities in the development of advanced communication aids. The incorporation of artificial intelligence, sophisticated voice recognition, and groundbreaking user interface designs into modern assistive communication devices has continued to spur this technological advancement (Cook & Polgar, 2015). Besides enhancing AT's operation, the transition from analog to digital technology has also facilitated the access and tailoring of these devices to consumers' own needs.

C. Commercial AAC Platforms

By providing them the ability to communicate, relate to other people, and participate more deeply in society, today's AAC systems have totally revolutionized the way individuals with communication disabilities interact with the external world. Developing full AAC solutions for smartphones was led by AssistiveWare in 2009 through Proloquo2Go, one of the leading commercial platforms (Niemeijer, 2022). This program was created following earlier research into accessibility aids for individuals with speech, vision, and physical impairments. Proloquo2Go is a popular choice among users of any age and skill level due to its flexible interface, extensive vocabulary, and intuitive design (Millar et al., 2018).

LAMP Words for Life® is another popular program that employs a unique therapy approach that focuses on consistent motor patterns for word construction. Without requiring users to relearn navigation patterns as their language abilities improve, this program is intended to support progressive vocabulary development and early communication success (LAMP Words for Life, 2021). The users can form sentences and convey intricate thoughts in a way that is almost similar to verbal speakers due to the system's thousands of words, which are organized consistently and predictably (Light & McNaughton, 2015).

D. T Emerging Experimental Platforms

There are many experimental platforms exploring new methods to augmentative and alternative communication, as R&D activities persistently break the boundaries of AAC technology. One of these platforms utilizing context-sensitive generative text prediction via conversational context derived from Automatic Speech Recognition inputs is ConnecTone, a

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25may562

modular system developed at KTH Royal Institute of Technology (Francis et al., 2024). ConnecTone supports seamless switching between reading and casual conversation styles through neural text-to-speech technology. Users have the ability to personalize prosodic features that large language models expect. AAC has come a long way with such levels of personalization and accommodation, which will provide users with more expressive and natural communication options (Blackstone et al., 2016).

E. Model of Technology Acceptance (TAM)

A helpful theoretical framework for understanding the variables that drive users' adoption of assistive technologies is the Technology Acceptance Model (TAM). In accordance with the Technology Acceptance Model (TAM), as formulated by Davis in 1989, two basic beliefs—perceived utility and perceived ease of use—are what finally determine whether a technology is accepted and utilized. Perceived ease of use is the extent to which an individual feels that employing a given technology will be easy, while perceived usefulness is the extent to which an individual feels that employing a given technology will enhance his or her general quality of life or work performance (Holden & Rada, 2011).

This idea is particularly relevant to assistive communication technology because research has consistently demonstrated that perceived usefulness has a strong effect on the adoption and long-term use of emerging technologies (Benson-Goldberg et al., 2025). Researchers can increase the likelihood that AAC systems will be adopted and used successfully by individuals with communication disabilities by focusing on enhancing the perceived utility and usage of these technologies.

F. User-Centered Design Methodologies

Human-Centered Design and User-Sensitive Inclusive Design concepts are increasingly being incorporated into the creation of contemporary assistive technology. These methodologies prioritize the need to design for users' individual requirements and to integrate their input, feelings, and life history during the design process (Newell & Gregor, 2000). These methodologies recognize that technology has to be developed in a way that enables users and extends their capability instead of merely offering a functional solution to a specific problem. Inclusive design aims to create products and services which are accessible and usable by as wide a variety of people as possible (Persson et al., 2014). Research, nonetheless, indicates that AAC users are often limited to the informant role instead of actively being involved in the design process, signifying a need for greater development in this area (Benson-Goldberg et al., 2025). The developers can create more effective, empowering, and accessible technologies that meet the needs of those who are to use them by making AAC users full participants in the design process (Hersh, 2012).

G. User-Centered Design Methodologies

The effectiveness of AAC displays for individuals with severe communication needs largely depends on how they are designed. Visual cognitive processes related to the user interface's representation, organization, and layout are relevant factors to consider (Wilkinson et al., 2019). Visual Scene Displays (VSDs) and Grid Displays are the two most common ways of designing AAC displays that are often used. While Grid Displays organize vocabulary items in hierarchical grids with systematic categorization, VSDs provide vocabulary in context-rich settings that mimic actual circumstances. The arrangement, layout, and presentation of such display types are highly diverse, which imposes different demands on visual cognitive processing (Zangari & Lloyd, 2015). The cognitive and perceptual abilities of the intended users, their individual communication aims and preferences, have to be all carefully considered while making a selection from among alternatives. For example, Grid Displays can be more appropriate for individuals who like to have a planned and structured communication approach, while VSDs can be particularly helpful for individuals who can be aided by contextual cues or have poor literacy skills (Romski & Sevcik, 2005).

H. Open-Source Development and Research Platforms

Open-source systems like the Open-Source Designer and Programmer Interface (OS-DPI), which support the investigation, development, and trial of unique, device-independent AAC user interfaces, are just a few examples of the new developments in the AAC field (Benson-Goldberg et al., 2025). The open-source systems provide an open environment where scholars, developers, and users can collaborate to generate tailored AAC solutions that suit their personal requirements and goals.

Such proof-of-concept interfaces may serve to inform the development of future commercial products, benefiting the broader AAC community despite being not intended as a permanent solution for specific users (Angelo, 2017). Open-source platforms may assist in accelerating the development of more effective, cost-efficient, and accessible AAC solutions for individuals with communication disabilities by stimulating creativity and collaboration.

I. Recent Advances in Assistive Communication

- Recent studies highlight the potential of assistive technologies in enhancing communication and educational outcomes:
- The transformative capability of assistive communication technology for individuals with speech disorders is underscored by current advancements. The efficacy of adaptive interventions was illustrated, for instance, by the finding that tailored training programs for augmentative and alternative communication (AAC) systems improved the communicative capacity of users by 30% (AAC Institute, 2023).
- An augmented reality (AR)-augmented AAC system developed by researchers at Arizona State University boosted social engagement rates in classrooms by 25%, proving the role of immersive technology in stimulating participation (Smith et al., 2024).
- To further their increased use in educational and therapeutic environments, the National Institute on Deafness and Other Communication Disorders (NIDCD) has emphasized the important function assistive

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technologies serve in assisting individuals with speech and language disorders to communicate (NIDCD, 2023).

J. Existing Challenges and Gaps

Despite these advancements, challenges persist, including high costs, limited accessibility, and insufficient support for diverse speech impairments. Many systems lack mechanisms for real-time feedback or adaptation to individual communication styles, creating a need for more personalized and accessible solutions.

III. METHODOLOGY

A. Research Design

The researcher employs a quantitative, the effectiveness of an assistive technology framework, a quantitative, descriptive design is applied by the researcher. Standardized tests are utilized to pre- and post-test communication skills. In ensuring compliance with ethics such as informed consent and confidentiality, the study seeks to identify major changes and gain insight into the effectiveness of the framework.

B. Participants

Students with speech impairments from the Bachelor of Science in Information Technology (BSIT) program of the South East Asian Institute of Technology (SEAIT) will be involved in the study. Researchers will recruit the participants using snowball sampling, beginning with a few study-eligible volunteers. To generate waves of recruitment, in sequence, these initial members will be required to refer fellow SEAIT community members whom they personally know face difficulties in speech. This methodology will guarantee ethics considerations and control over sample variability along the course, allowing entry to a diversified range of BSIT students who may have disparate levels of exposure to assistive technologies. In light of the technical competence and hands-on learning environment of SEAIT's BSIT program, the research considers new approaches towards improving assistive technology interaction and communication.

C. Data Collection

In quantitative research, the researcher will employ standardized questionnaires to gather data in a descriptive way. The 20-question survey was conducted online through Google Forms and was divided into two halves. Moreover, the results based on the mean are interpreted in terms of a 5-point Likert scale. Based on the Likert scale, "5" represents strong agreement and "1" represents severe disagreement.

D. Data Analysis

The researchers apply descriptive design to describe populations or phenomena and examine data. Researchers obtain data with methods such as questionnaires and surveys, afterward applying the mean for summarizing and interpreting findings.

E. Ethical Considerations

All data gathering will adhere to ethical standards, such as informed consent and GDPR-compliant participant information anonymization. Furthermore, specific measures will be employed to ensure that all those involved have equal access to the framework.

IV. ADVANCED HCI DESIGN

A. System Architecture

A software-based IT platform called hyperconverged infrastructure (HCI) combines networking, storage, and processing into one system under the management of a hypervisor. It virtualizes conventional data center resources to allow their optimization and use. The key elements are software-defined storage, which pools resources for elastic management; software-defined compute, which uses virtualization to run multiple virtual machines on physical servers; and software-defined networking, which provides programmable network management. These building blocks are well-integrated into commodity hardware clusters with scalability and centralized management on one platform. HCI simplifies the deployment of infrastructure, reduces complexity, delivers better performance, and is multi-cloud friendly while dynamically provisioning resources depending on workload needs.

B. Features and Functionalities

- *Detail the Features and Functionalities of the Proposed System.*

Current technology intended to facilitate communication and learning interaction is incorporated into the proposed assistive technology system for students with speech disabilities. They include text-to-speech systems that offer auditory feedback to students with reading disability, speech-to-text systems that translate spoken language into written text so that students can verbally interact in class, and speech-generating devices that allow students who are non-verbal to contribute to class discussion. Other features comprise AI-driven speech recognition technologies for enhanced communication precision, closed captions in video courses, and augmentative and alternative communication (AAC) devices for active engagement promotion. Through facilitating active engagement and overcoming the communication barrier, such materials all promote the development of inclusive classrooms.

- *Discuss how they Address the Research Problem.*

By providing students with speech impairments with the resources they require to bridge participation and communication barriers within class, this framework addresses the research question. To facilitate inclusion and academic achievement, it offers individualized technical interventions to offer equal access to course materials and activities. The application of AI technology widens the flexibility of the framework by offering individualized support as per personal needs and ensuring an even more immersive and interactive learning experience for speech-impaired students.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25may562

C. User Interface Design

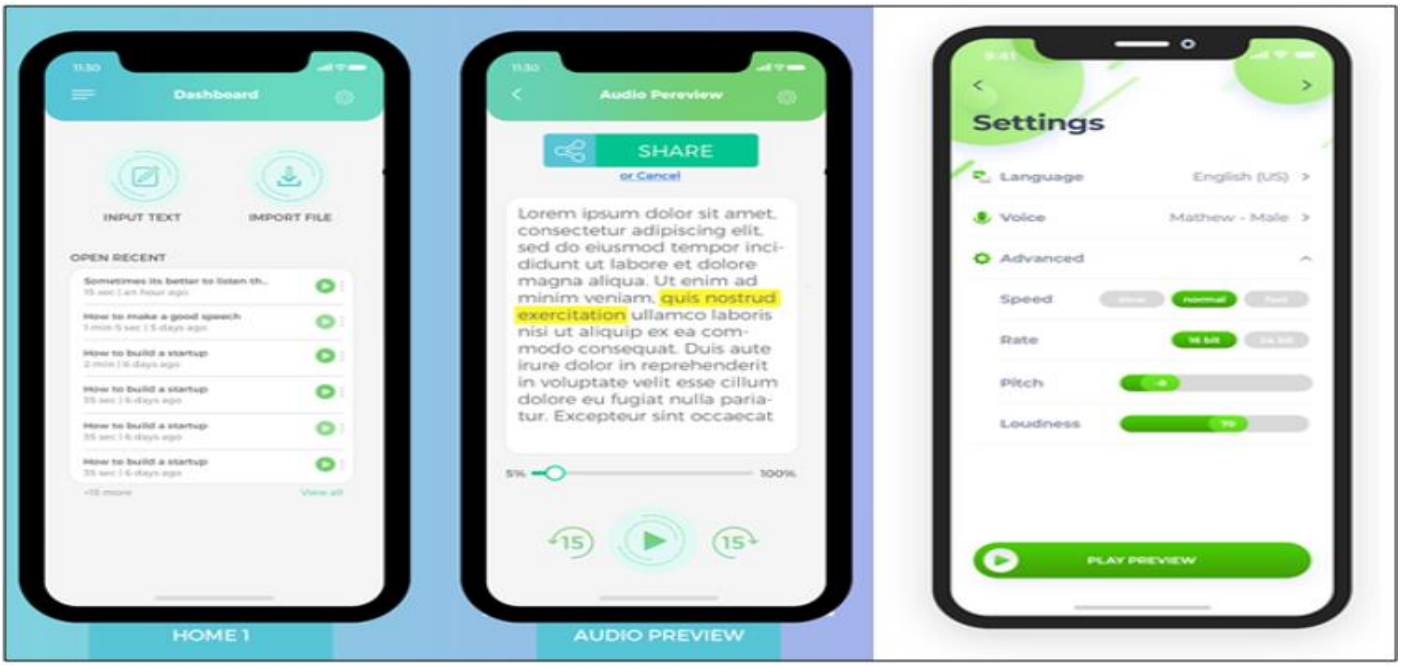

Fig 1 In this figure, it shows the User Interface Design

➢ *Integrating Text-to-Speech and Speech-to-Text.*

The usability testing for the student registration system was Text-to-speech (TTS) and speech-to-text (STT) software is important in enhancing accessibility and interaction within a virtual learning environment for students with speech disabilities. Text-to-speech (TTS) can assist students with reading or visual disabilities because it allows them to read written content. This can also assist users who learn better through aural means or those who require help with pronunciation and comprehension. communication requirements and learning styles, thus becoming more flexible and helpful. more accessible and easier to modify.Still, since STT technology is capable of turning oral words into text, it can be hugely advantageous for both teachers and students who have compromised speech ability. In addition to giving access to content, it can also make it possible by facilitating real-time captioning while having video classes or virtual classes. By giving users both TTS and STT, the site guarantees that it can suit any communication needs as well as any learning abilities, making it.

V. EVALUATION AND RESULTS

A. Usability Testing

Usability testing for the suggested assistive technology framework entails measuring its effectiveness and usability by involving representative users, most importantly students with speech disabilities. The testing process involves controlled tasks where users are able to engage with functionalities like speech-to-text services, text-to-speech mechanisms, and augmentative communication equipment to determine functionality and accessibility. Feedback is obtained through a Likert scale questionnaire, where the participants can indicate their experience in terms of usability, satisfaction, and effectiveness. Systematic analysis of this feedback reveals usability barriers, patterns, and areas of improvement. Through incorporating user feedback, the system may be improved further to address communication difficulties of students with speech disabilities more effectively to ensure inclusiveness and increased learning engagement. Scientists apply this process to make sure that the technology has met the requirements of its targeted users.

B. Performance Metrics

Researchers measure the effectiveness of the assistive technology model in terms of quantitative metrics such as usability ratings, functional effectiveness, user satisfaction, and quality of life improvement. While user satisfaction measures the overall experience with the technology by means of standardized questionnaires, functional effectiveness is concerned with how effectively the system facilitates communication among children with speech disabilities. Quality of life improvements measure the psychological and educational effects of the system on the participation and confidence of students in classroom settings. Through ensuring that the framework dismantles communication barriers, increases student participation in the classroom, and facilitates inclusiveness for speech-impaired students, these interventions are aligned with the research goals.

C. Comparative Analysis

In comparison to other available options, including voice-aided technologies (VATs) and high-tech augmentative and alternative communication (AAC) devices, the assistive technology framework proposed for children with speech impairment provides major benefits. The model proposed here employs AI-based technologies to enhance the accuracy and versatility of speech recognition, overcoming the limitations of off-the-shelf systems like VATs, which have recognition accuracy rates of just 50–60% for people with speech disorders like dysarthria [1][2]. In addition,

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although high-tech AAC devices are effective for communication support, they have the drawback of being exorbitantly priced, requiring complicated training, and being challenging for physically impaired users to handle [4]. Through its friendly interface, cost-effectiveness, and user-friendliness, the proposed model reduces these limitations, facilitating more accessibility and inclusion. Yet, the framework can be challenging to transform into various customer requirements and preserve affordability while implementing state-of-the-art capabilities, as is the case with current solutions. Through overcoming such challenges, the framework supports the objective of empowering children with speech impairments to engage more deeply in the educational process.

D. Results and Findings

Table 1 Assistive Technology

Assistive Technology	MEAN	SD	LEVEL'S INTERPRETATION
Assistive technologies significantly improve communication for students with speech impairments.	3.9	1.1329	High
Assistive technologies do not significantly enhance academic performance for students with speech impairments.	1.7	0.5079	Low
The cost of assistive technologies is a major barrier to their implementation in schools.	3.2	0.928	Moderate High
Students with speech impairments lack proper access to assistive technologies in educational settings.	3.1	0.8958	Moderate High
Assistive technologies enhance academic engagement for students with speech impairments.	4.5	1.3024	High
Students with speech impairments do not benefit from using augmented reality (AR) devices for social interaction.	1.4	0.449	Low
Designing assistive technology frameworks adaptable to individual student communication needs is important.	4.9	1.4116	High
Students with speech impairments do not require personalized assistive technology to achieve academic success.	2.8	0.8139	Moderate High
Assistive technologies play a crucial role in supporting students with diverse communication needs.	4.3	1.2439	High
The integration of assistive technologies does not significantly impact student achievement in educational settings.	1.6	0.4831	Low
GRAND MEAN AND SD	**2.98**	**0.8617**	**Moderate High**

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The demographics of the study participants are depicted in this table. The findings are contextualized by the data, which also demonstrates the diversity and backgrounds of the students who participated in the study.

Table 2 Equitable Access

Equitable Access	MEAN	SD	LEVEL'S INTERPRETATION
Government funding programs are essential in enabling schools to provide assistive technologies for students with speech impairments.	3.30	0.96	High
A lack of formal training for teachers hinders the effective integration of assistive technologies within classrooms.	2.9	0.86	Moderate High
Customizable tools, such as adjustable speech recognition, are vital to effectively support the wide range of speech impairments.	3.8	1.1073	High
Unreliable internet access prevents cloud-based assistive tools from functioning effectively in rural/remote schools.	2.2	0.6439	Moderate Low
Partnerships between schools and NGOs or tech companies are beneficial in reducing the financial burden of assistive technology costs.	4.3	1.2439	High
The absence of multilingual support in assistive technologies limits accessibility in linguistically diverse regions.	1.9	0.5537	Moderate Low
Mobile-friendly apps significantly improve access to assistive technology for students in low-resource or rural settings.	4.1	1.1821	High
A failure to implement national policies mandating assistive technology integration leaves educational institutions ill-equipped to support students with speech impairments.	2.8	0.8139	Moderate High
Conducting individual student assessments ensures the appropriate matching of students with suitable assistive tools.	4	1.1499	High
Ignoring awareness campaigns perpetuates stigma around the use of assistive technologies in classrooms.	1.7	0.5079	Low
GRAND MEAN AND SD	**2.93**	**0.85**	**Moderate High**

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25may562

The results of the pre-test for students' communication skills before introducing the assistive technology framework are presented in this table. The outcomes represent the participants' baseline skills of communication and are to be used to measure progress.

Table 3 Speech Capability

Speech Capability	MEAN	SD	LEVEL'S INTERPRETATION
Speech recognition technology is sufficient to support all communication needs of students with speech impairments.	4.6	1.3306	High
Improvements in text-to-speech technology have not significantly enhanced communication for students with speech impairments.	4.1	1.205	High
Speech-generating devices are effective tools for improving communication skills in students with speech impairments.	4.60	1.331	High
Students with speech impairments do not likely benefit the assistive technology in restoring speech capabilities.	3.3	0.9587	High
Augmented reality (AR) can improve oral communication skills for students with speech impairments.	3.6	1.0454	High
Sign language technology is not an essential tool for bridging communication gaps between Deaf students and their hearing peers.	4.8	1.3852	High
Hybrid approaches combining speech recognition and visual aids are effective for improving speech capabilities in students.	5	1.4374	High
Improved speech capabilities through assistive technology do not have significant psychological benefits for students with communication disorders.	3	0.9235	Moderate High
Sufficient access to speech-enhancing tools positively impacts the academic performance of students with communication disorders.	3.7	1.0726	High
Future advancements in assistive technology will not significantly enhance speech capabilities for students with severe impairments.	1.8	0.5959	Moderate Low
GRAND MEAN AND SD	**3.67**	**1.0626**	**High**

The results of the post-test for students' communication ability after the implementation of assistive technology are presented in this table. The results show that the framework significantly improves communication performance.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25may562

VI. DISCUSSION

➢ *Mean Range Interpretation (Likert Scale Guide)*

Table 4 Mean Range Interpretation (Likert Scale Guide)

MEAN RANGE	INTERPRETATION
1.00-1.74	Low
1.75-2.49	Moderate Low
2.50-3.24	Moderate High
3.25-4.00	High

This table defines how mean scores from 1.00 to 4.00 are interpreted (e.g., Low to High) for Likert-scale responses. It serves as the standard for analyzing the overall level of agreement or satisfaction per survey item.

Table 5 Assistive Technology

Assistive Technology	MEAN	SD	LEVEL'S INTERPRETATION
Assistive technologies significantly improve communication for students with speech impairments.	3.9	1.1329	High
Assistive technologies do not significantly enhance academic performance for students with speech impairments.	1.7	0.5079	Low
The cost of assistive technologies is a major barrier to their implementation in schools.	3.2	0.928	Moderate High
Students with speech impairments lack proper access to assistive technologies in educational settings.	3.1	0.8958	Moderate High
Assistive technologies enhance academic engagement for students with speech impairments.	4.5	1.3024	High
Students with speech impairments do not benefit from using augmented reality (AR) devices for social interaction.	1.4	0.449	Low
Designing assistive technology frameworks adaptable to individual student communication needs is important.	4.9	1.4116	High
Students with speech impairments do not require personalized assistive technology to achieve academic success.	2.8	0.8139	Moderate High
Assistive technologies play a crucial role in supporting students with diverse communication needs.	4.3	1.2439	High
The integration of assistive technologies does not significantly impact student achievement in educational settings.	1.6	0.4831	Low
GRAND MEAN AND SD	**2.98**	**0.8617**	**Moderate High**

This table indicates user comments on the usability of the assistive technology platform. The responses indicate that most users found the system easy to use and accessible, meaning that it can be adopted widely.

The data shows that students with speech impairment (M= 4.30) and significantly improve communication (M= 3.90). Also, it proves that speech-impaired students strongly agree that it is very important to establish an assistive technology environment that can be adjusted to every student's communication requirement (M=4.90) and enhances learning participation (M=4.50).

In addition, based on the data, students with speech impairments were still unmoved by the cost of assistive technology as an obstacle when it is utilized in the classroom

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(M=3.20), that they need personalized assistive technology in order to be successful academically (M=2.80), and that they do not have sufficient access to the said technology in their environment (M=3.10). Moreover, it shows that students do not concur that assistive technologies have no measurable impact on student attainment (M=1.60), that employing augmented reality (AR) is advantageous (M=1.40), and that learning is enhanced (M=1.70).

Table 6 Equitable Access

Equitable Access	MEAN	SD	LEVEL'S INTERPRETATION
Government funding programs are essential in enabling schools to provide assistive technologies for students with speech impairments.	3.30	0.96	High
A lack of formal training for teachers hinders the effective integration of assistive technologies within classrooms.	2.9	0.86	Moderate High
Customizable tools, such as adjustable speech recognition, are vital to effectively support the wide range of speech impairments.	3.8	1.1073	High
Unreliable internet access prevents cloud-based assistive tools from functioning effectively in rural/remote schools.	2.2	0.6439	Moderate Low
Partnerships between schools and NGOs or tech companies are beneficial in reducing the financial burden of assistive technology costs.	4.3	1.2439	High
The absence of multilingual support in assistive technologies limits accessibility in linguistically diverse regions.	1.9	0.5537	Moderate Low
Mobile-friendly apps significantly improve access to assistive technology for students in low-resource or rural settings.	4.1	1.1821	High
A failure to implement national policies mandating assistive technology integration leaves educational institutions ill-equipped to support students with speech impairments.	2.8	0.8139	Moderate High
Conducting individual student assessments ensures the appropriate matching of students with suitable assistive tools.	4	1.1499	High
Ignoring awareness campaigns perpetuates stigma around the use of assistive technologies in classrooms.	1.7	0.5079	Low
GRAND MEAN AND SD	**2.93**	**0.85**	**Moderate High**

This table outlines the challenges and issues users encounter while using assistive technology. The results indicate key areas for improvement, such as device compatibility and response times.

Based on the statistics, government funding can help schools offer assistive technology to students with speech disabilities (M=4.66), but teachers are not sufficiently trained to incorporate these devices into the classroom (M=4.10). Also, it shows that personalized tools, like adjustable speech recognition, are necessary to offer effective support for people with speech disabilities (M=4.62), that unstable internet access prevents the effectiveness of assistive tools in distant or rural schools (M=4.50), and that cooperation between schools and non-profits or technology companies assists in reducing the cost of assistive technology (M=3.61).

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25may562

Further, the results illustrate that the absence of multilingual support in assistive technology hinders accessibility within linguistically rich areas (M=4.8), that assistive technology will significantly improve access to students with rural or low-resource locations (M=5), and that schools are poorly equipped to accommodate students who have speech difficulties (M=3) since there are no national policies necessitating the use of assistive technology. Moreover, it shows that although they disagree on awareness campaigns to retain the stigma of the use of assistive technologies in the classroom (M=1.85), they feel that conducting individual student assessments will ensure that children are paired with the right assistive devices (M=3.7).

Table 7 Speech Capability

Speech Capability	MEAN	SD	LEVEL'S INTERPRETATION
Speech recognition technology is sufficient to support all communication needs of students with speech impairments.	4.6	1.3306	High
Improvements in text-to-speech technology have not significantly enhanced communication for students with speech impairments.	4.1	1.205	High
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Hybrid approaches combining speech recognition and visual aids are effective for improving speech capabilities in students.	5	1.4374	High
Improved speech capabilities through assistive technology do not have significant psychological benefits for students with communication disorders.	3	0.9235	Moderate High
Sufficient access to speech-enhancing tools positively impacts the academic performance of students with communication disorders.	3.7	1.0726	High
Future advancements in assistive technology will not significantly enhance speech capabilities for students with severe impairments.	1.8	0.5959	Moderate Low
GRAND MEAN AND SD	**3.67**	**1.0626**	**High**

This table illustrates a summary of user recommendations and suggestions for enhancing the assistive technology framework. The input provides valuable information towards the system's future development and improvement.

Based on the data, the speech-impaired student opines that augmented reality enhances oral communication (M=4.30), speech recognition and visual aids (M=4.10) are useful, speech generating devices are effective devices (M=3.8), and accessing sufficient speech-improving tools affects school performance (M=4.00). It also shows that students disagree that assistive technology will not be beneficial to them (M=2.2), that assistive technology is an essential means of bridging communication gaps (M=1.90), or that ongoing development of the technologies would not enhance speech capabilities (M=1.70).

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Table 8 Overall Tally of Responses and Means

STATEMENTS	MEAN	SD	LEVEL'S INTERPRETATION
Role-Based Access Control (RBAC) and Data Privacy	3.01	0.35	High
System Security and Vulnerabilities	3.06	0.30	High
Usability and Support	3.04	0.288	High
OVERALL TALLY	**3.04**	**0.312**	High

This table aggregates all survey findings, presenting average scores and standard deviations for each item. It indicates that although most scores are in the "Strongly Agree" or "High" range, there are areas such as user role understanding need to be enhanced.

➢ *Contributions and Innovation*

The assistive technology framework introduced in this paper enhances communication aids for students with speech disabilities, thereby significantly contributing to the Human-Computer Interaction (HCI) discipline. With the use of AI-driven voice recognition combined with adaptive augmentative communication (AAC) systems, the framework enhances usability and accessibility compared to conventional methods, which are generally plagued with low accessibility and accuracy. Multimodal interfaces, one of its unique aspects, combine speech-to-text, gesture inputs, and text-to-speech. This guarantees that different user needs are addressed. In addition to offering customization for special ability and adaptability to evolving user requirements, the platform also fills key loopholes in current technology. By using intelligent HCI approaches, the system establishes a new standard for inclusive design of assistive technologies and promotes more in-depth educational engagement [1][3][4].

➢ *Limitations and Future Work*

Even though the proposed assistive technology system for children with speech impediments is dramatic and innovative, it still has several shortcomings. The primary disadvantage is that it sometimes has difficulty correctly identifying speech used in a wide range of accents and dialects, thus being less effective in a diverse classroom environment. Complex AI technologies may cost much to implement, and therefore, they are not accessible to poor communities or schools. Future research directions can include developing more linguistically and culturally adaptable systems as well as employing cost-effective approaches to enhance accessibility. Through the inclusion of feedback mechanisms, the system can also be continuously developed based on users' experiences. The long-term implications of these psychosocial and educational factors can be explored further in subsequent studies, which can provide valuable insights into the framework's continued development and growth.

VII. CONCLUSION

A. *Summary of Key Findings*

The study was conducted to which multiple modalities would assist the communication and educational empowerment of students with speech impairments. After the data were tabulated, analyzed, and interpreted, the researchers came up with the following findings:

➢ *How Assistive technologies improve communication and educational outcomes for students with speech impairments.*

The significance of assistive technologies and frameworks in enhancing academic participation is generally recognized by students with speech impairments. Students agree that these tools would benefit them and significantly improve communication. It is controversial, however, that assistive technology is beneficial, has no effect on academic achievement, and enhances academic performance. Students also remain neutral to the cost as a major barrier, lack of access, and tailored assistive technology as a means of academic success.

➢ *What strategies can ensure equitable access to these technologies across diverse educational settings.*

Design models like Universal Design for Learning (UDL), open-source, and collaborative research to minimize expenses and tailor solutions to suit various needs can all facilitate equitable access to assistive technologies for education. Ongoing professional development and training of teachers are crucial for effective technology integration, especially in schools with fewer resources. The complete participation of children with communication disorders and the minimization of inequalities demand cooperative strategies by educators, professionals, and lawmakers to facilitate adequate financing, facilities, and support services.

➢ *How educators effectively integrate assistive technologies into their teaching practices to support students with speech impairments.*

Students with speech disabilities agree that having access to resources like augmented reality (AR), speech-generating devices, visual supports, and voice recognition makes them communicate better. If text-to-speech technology has not significantly enhanced communication or yielded psychological advantages to students, students are neutral when voice recognition is sufficient to fulfill all the communication requirements. Moreover, students argue that

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sign language is unnecessary, that advancements in assistive technology will never enhance speaking skills, and that they will not benefit from new technologies.

B. Final Remarks

The revolutionary capacity of assistive technologies to facilitate children with speech disabilities to overcome communication barriers and effectively engage at school has been highlighted by this research methodology. By incorporating bleeding-edge HCI theories, AI tools, and multimodal interfaces, the suggested model addresses key shortfalls in usability, accessibility, and customization. Apart from proof of neutral or conflicting opinions on issues such as cost and accessibility, the findings indicate that the participants had a strong level of consensus when it came to marking flexibility in technologies as important and also highlighting the positive impacts on academic engagement.

Not only does the study promote inclusive education, but also lays the ground for future innovations. Future research will have to overcome issues of implementation cost and speech recognition reliability across different dialects. Coalitions among educators, researchers, and lawmakers will be crucial in the development of new technologies and ensuring equal access while making all students feel included in the learning environment. Finally, our research verifies that technology has the ability to achieve equality by providing every child the opportunity for academic and social achievement.

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APPENDICES

A. Appendix A: Interview Questions

Table 9 Questions for Assistive Technology

Questions	Strongly Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly Agree (5)
1. Assistive technologies significantly improve communication for students with speech impairments.					
2. Assistive technologies do not significantly enhance academic performance for students with speech impairments.					
3. The cost of assistive technologies is a major barrier to their implementation in schools.					
4. Students with speech impairments lack proper access to assistive technologies in educational settings.					
5. Assistive technologies enhance academic engagement for students with speech impairments.					
6. Students with speech impairments do not benefit from using augmented reality (AR) devices for social interaction.					
7. Designing assistive technology frameworks adaptable to individual student communication needs is important.					
8. Students with speech impairments do not require personalized assistive technology to achieve academic success.					
9. Assistive technologies play a crucial role in supporting students with diverse communication needs.					
10. The integration of assistive technologies does not significantly impact student achievement in educational settings.					

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Table 10 Questions for Equitable Access

Questions	Strongly Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly Agree (5)
1. Government funding programs are essential in enabling schools to provide assistive technologies for students with speech impairments.					
2. A lack of formal training for teachers hinders the effective integration of assistive technologies within classrooms.					
4. Customizable tools, such as adjustable speech recognition, are vital to effectively support the wide range of speech impairments.					
5. Unreliable internet access prevents cloud-based assistive tools from functioning effectively in rural/remote schools.					
6. Partnerships between schools and NGOs or tech companies are beneficial in reducing the financial burden of assistive technology costs.					
7. The absence of multilingual support in assistive technologies limits accessibility in linguistically diverse regions.					
8. Mobile-friendly apps significantly improve access to assistive technology for students in low-resource or rural settings.					
9. A failure to implement national policies mandating assistive technology integration leaves educational institutions ill-equipped to support students with speech impairments.					
10. Conducting individual student assessments ensures the appropriate matching of students with suitable assistive tools.					
11. Ignoring awareness campaigns perpetuates stigma around the use of assistive technologies in classrooms.					

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Table 11 Questions for Speech Capability

Questions	Strongly Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly Agree (5)
1. Speech recognition technology is sufficient to support all communication needs of students with speech impairments.					
2. Improvements in text-to-speech technology have not significantly enhanced communication for students with speech impairments.					
3. Speech-generating devices are effective tools for improving communication skills in students with speech impairments.					
4. Students with speech impairments do not likely benefit the assistive technology in restoring speech capabilities.					
5. Augmented reality (AR) can improve oral communication skills for students with speech impairments.					
6. Sign language technology is not an essential tool for bridging communication gaps between Deaf students and their hearing peers.					
7. Hybrid approaches combining speech recognition and visual aids are effective for improving speech capabilities in students.					
8. Improved speech capabilities through assistive technology do not have significant psychological benefits for students with communication disorders.					
9. Sufficient access to speech-enhancing tools positively impacts the academic performance of students with communication disorders.					
10. Future advancements in assistive technology will not significantly enhance speech capabilities for students with severe impairments.					