ASHESI UNIVERSITY

AN INTELLIGENT E-LEARNING SYSTEM TO PROMOTE AN INCLUSIVE

CLASSROOM EXPERIENCE FOR DEAF

AND HARD OF HEARING STUDENTS IN A GHANAIAN UNIVERSITY

UNDERGRADUATE THESIS

B.Sc. Computer Science

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An Intelligent E-Learning System for Deaf/Hard of Hearing Students in a Ghanaian University

UNDERGRADUATE THESIS

Thesis submitted to the Department of Computer Science, Ashesi University in partial fulfillment of the requirements for the award of Bachelor of Science degree in Computer Science

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DECLARATION

I, hereby declare that this Undergraduate Thesis is the result of my original work and that no part of it has been presented for another degree in this University or elsewhere.

Candidate's Signature:

Candidate's Name:

Date:

I hereby declare that preparation and presentation of this Undergraduate Thesis were supervised in accordance with the guidelines on supervision of Undergraduate Thesis laid down by Ashesi University.

Supervisor's Signature:

Supervisor's Name:

Date:

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Abstract

Millions of persons with disabilities living in low-income countries cannot access either primary, secondary, or tertiary education due to the lack of infrastructure, digital tools, and devices that promote inclusive learning. According to a definition given by UNESCO, "inclusive education means including student with disabilities in the mainstream school environment"[33]. This research addresses the project theme of developing an intelligent learning system to enhance an inclusive classroom experience for Deaf/Hard of Hearing students (D/HH) in a Ghanaian university. The aim of this research is to identify how an E-learning system can improve the English abilities of Deaf students in a tertiary institution which is in line with the mandate of the fourth Sustainable Development Goal (S.D.G.4) of "Quality Education for all". Data is collected from primary sources through surveys and focus groups with identified D/HH students, School Administrators, and teachers of D/HH students.

This paper answers the research question "*How can an E-learning system support an inclusive classroom experience for D/HH students in a Ghanaian university?*". The results of this research will shape how an E-learning system can be adopted to support inclusive education in various tertiary institutions across Ghana.

Keywords: Deaf/ Hard of Hearing, Intelligent E-learning system

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Chapter 1: Introduction

1.1 Overview of Disability

Disability is described as a human condition which many people are exposed to at one point or the other in their lives which may lead to permanent or temporal disability [14]. According to a report from the World Health Organization (WHO), there are over one billion people (15% of the world population) that experience some form of disability such as blindness, hearing loss, amongst others [11].

The United Nations Development Program has estimated that 80% of persons with disabilities live in developing counties and 90% of children living with a disability in developing countries are not in school [10]. In Ghana, persons with disability accounts for 3.7% of the population [30]. Out of the different categories of disabilities, the WHO estimates that 5% of persons in the world suffer from hearing loss and it is projected that by 2050 nearly 2.5 billion people will have some degree of hearing loss [11]. In Ghana, as of 2019, the number of Deaf people as reported by the Ghana Statistical Service was 211,712 [21].

People with disabilities experience several challenges such as poor health, lower education achievements, fewer economic opportunities than people without disabilities which leads to higher poverty rates [10]. Students with disabilities in Organization for Economic Co-operation and Development (OECD) countries remain under-represented in higher education and this number is on the rise [10]. This is due to the absence of Information Communication and Technology (I.C.T.) tools that will help the students in their educational activities at all levels.

UNESCO stated that "I.C.T.'s can be a valuable tool for learners with disabilities who are negatively affected by the digital divide and exclusion from educational opportunities" [23]. Using inclusive I.C.T.'s, assistive technology and other tools will reduce barriers and grant persons with disabilities access to educational opportunities [23]. The term *Inclusive education* refers to the process of educating students with disabilities with non-disabled students in the same school or classroom [4]. Inclusive education will increase access to learning and produce a higher number of educated and skilled people with disabilities [36].

Article 24 (2)b of the United Nations Convention on the Rights of Persons with Disabilities (UNCRPD) states that persons with disabilities have the right to equal participation in education [35]. Therefore, conscious efforts are being made towards an inclusive education that ensures interventions that minimize children's barriers to learning without exclusion [33]. This aligns with the United Nations Sustainable Development Goal 4 (S.D.G. 4), of quality education which includes people with disabilities [16].

The combined efforts of many world organizations such as WHO, UNCRPD and others have increased the advocacy of educational rights and support of persons with disabilities across the world. However, not much progress is seen in developing countries like Ghana where the Deaf students in tertiary institutions do not have access to adequate assistive technologies, systems, and tools that allows the education of Deaf students and hearing students in a classroom [14]. Therefore, this paper seeks to identify how an E-learning system can support the education of Deaf/Hard of Hearing students alongside hearing students in a standard Ghanaian university classroom.

1.1.1 Definition of Terms

- **Hearing impairment:** "It covers a spectrum of hearing losses ranging from mild to profound" [27].

- **Normal hearing:** In Ghana, normal hearing is the level at which sound is detected and this is between 0-25 [27].

- **Hard of Hearing:** students who have hearing loss of 26-70dB hearing Level (HL). These individuals may sometimes be able to pick up some sounds in a quiet environment with less extensive vocabulary [27].

- **Deaf:** students who have hearing loss of 71-90dB and cannot hear any sound whatsoever and cannot benefit from any form of oral communication [27].

- **Prelingual deafness:** hearing loss at birth, early childhood or before exposure to spoken language [27].

- **Post lingual deafnes**s: this deafness occurs after speech and language has been acquired [27].

1.2 Background Work

Between 2006 and 2016, the University of Education, Winneba, admitted 26 qualified D/HH from the Ghanaian Deaf Cultural community into four-year bachelor's degree programs [14]. This number represents a tiny percentage of the thousands of D/HI students seeking a bachelor's degree across the country which means that more universities need to provide inclusive education environments. To increase the maximum participation of D/HH in an inclusive classroom, manual methods and reliance on the Ghanaian Sign Language to

administer lecture contents in an inclusive classroom environment will not be sufficient. Thus, there is a need to use learning systems that will incorporate speech to text transcriptions, and captions that will enable D/HH to understand lectures. Other challenges identified with the manual method of inclusive education is the shortage of sign language interpreters to serve D/HH students in universities. Some of the students in one of the public universities mentioned above, complained about the interpreting style when a 'new' sign language interpreter takes over from an 'old' sign language interpreter [14]. This reveals the need for government bodies to standardize the Ghanaian Sign Language at all levels of educational institutions to avoid confusing the D/HH students.

Furthermore, in Ghana, all the universities that accommodate the education of D/HH and hearing students in a classroom are mainly public universities and they include: University of Education, Winneba (U.E.W.), University of Cape Coast, and the University of Ghana Legon. Each of these universities admit several D/HH students in a lecture room together with the hearing students. Most of these universities rely heavily on sign language as the primary mode of communication with D/HH students in an inclusive classroom. The D/HH students attend lectures through the help of a trained sign language professional who serves as a sign language interpreter that translates the lecturer's information into sign language, and a note-taker who takes notes for the student as they pay attention to the interpreter [14]. Also, the D/HH students are made to sit in the front row of the classrooms so that they can read the lips of the lecturers.

1.3 Problem Statement

The Ghanaian Sign Language (GSL) is the primary means of communication with

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D/HH in universities that accommodate D/HH and hearing students in a classroom. However, since the GSL has not yet been standardized, D/HH face the challenge of managing different sign representation for particular words [21] Additionally, majority of D/HH students have very low writing and comprehension abilities of the English language when compared to their hearing persons. This is because GSL does not have the same rules in vocabulary identification, constructing syntactic phrases, figurative language or making sentences with conjunctions like 'and', 'is' 'but', and many more [21]. Therefore, D/HH students in tertiary institutions need to be supported with systems that incorporate speech-to-text applications, subtitles, or lip-reading applications used during lectures in an inclusive classroom [14]. Thus, this research seeks to answer the question: "*How can an E-learning system improve the English abilities and comprehension abilities of D/HH students in a Ghanaian university?*"

1.4 Motivation

The motivation for this research stems from the number of challenges faced by Persons with Disabilities (P.W.D) including D/HH and the role of technology in mitigating some of these challenges.

The table below highlights quotes from an independent private research carried out on P.W.D. This provides insights into the challenges and barriers faced by P.W.D. All responses are anonymous for confidentiality purposes. The number in the respondent section represents responses from different respondents.

Table 1.0: A private and independent study to understand the challenges faced by Persons with Disabilities

THEMES	RESPONDENTS
Need for financial support	1. "I think helping students financially will help, yes.". 2. "Yes, the financial support is important because most people get to drop out because of financial problems. I applied to my district, and then they told me that they can't help me because I attend a private school, not a government school, so they cannot help me.". 3. "I'm not from a good home, financially seems we had a financial crisis. There was nothing I could do. My mum is a single parent, so she took care of my sibling and me, and I say I felt she was even fed up with me,she spent a lot on me since this happened, me being physically challenged."
Equality	1."They should treat us with equal term treatment as errrm those who are able". 2. "errm people living with errm disabilities should be given equal attention as the able people in everything because errrm no one wishes to be physically challenged or no one chose to be disabled, so if unfortunately, some of us find ourselves in this condition errmm lecturers, other people shouldn't see us to be errm some strange people coming from a different planet."
Social misconception of	1. "Things were not moving on well like because you are a person with disability people have different mind-sets about you; some are tagging

P.W.D.'s	you that you are a witch some are saying you are an imbecile, like a curse. So, making friends was a difficult journey". 2. "Someone can see you and then the way the person will look at you, so you feel like you are not part of humans. At times when you go to the public, I'm that type I find it very difficult to be in public because when you are during, should, I say, able people, they all look at you, and at that instance, it's like I'm not a human being? Like, let me vanish. No one should see me. They all focus their attention on you." 3. "Well, yeah, especially with the society you find yourself in. You know I had. I'm the kind of person that I like[7] laughing a lot. I had so many friends, but after my disability, I lost all my friends." 4."Okay, some of the family members will even encourage the parents not to send their children to school or their wards to school just because they feel they can't do anything or what they can do is limited."

1.5 Project Aim, Objectives, and Research Question

This research aims to build an efficient, intelligent E-learning system to support an inclusive classroom experience for D/HH students in a Ghanaian tertiary institution. To keep the classroom experience of D/HH students, the learning system will contain specific technologies and resources tailored to meet the needs of the students.

Below is a definition of the following keywords mentioned above ("intelligent system," "inclusive education," "e-learning").

An intelligent system can generally be seen as a tool designed to perform a task that requires intelligence [26]. However, other researchers further explained that "an intelligent system is a system that emulates some aspects of intelligence exhibited by nature. These include learning, adaptability, robustness across problem domains, improving efficiency (over time and space), information compression (data to knowledge), extrapolated reasoning" [29].

To elaborate on the term "inclusive education," UNESCO views inclusion as "a dynamic approach of responding positively to pupil diversity and of seeing individual differences not as problems, but as opportunities for enriching learning" [35]. Thus, inclusive education is the process of providing all students with equal educational opportunities and ensuring that those with diverse needs and preferences (such as persons with disabilities) can have equal opportunities in accessing learning resources, and services [It is seen to reduce inequalities and increase the competencies of all people including P.W.D[35].

For this research, the "learning system" referred to here is an E-learning system, and a few researchers have captured different definitions of an E-learning system.

"E-learning uses electronic media for various learning purposes that range from add-on functions in conventional classrooms to full substitution for face-to-face meetings by online encounters" [18].

"E-learning is defined as information and communication technologies used to support students to improve their learning" (Nati et al., 2012; Ellis, Ginns & Piggott, 2009).

"E-learning refers to educational processes that utilize information and communications technology to mediate synchronous and asynchronous learning and teaching activities" [18].

Furthermore, the objectives of this research include:

- **OB1:** Identify an effective way to improve the English abilities of D/HH students.

- **OB2:** Build a system that incorporates existing technologies that will support the classroom experience of D/HH students, i.e., to access course materials, participate in class discussions, and attend an in-person class.

- **OB3:** Identify a set of mechanisms and structures which will serve as policy recommendations that tertiary institutions in Ghana can use to support inclusive education for D/HH persons.

- **OB4:** Identify the problems that affect and limit persons with disabilities from accessing tertiary education.

The aim and objectives outlined above will be addressed by the research questions stated below:

R.Q.: How can an E-learning system support an inclusive classroom experience for D/HH students in a Ghanaian university? To probe further, this research question is broken down to sub-questions which include:

- **RQ1:** What features can be incorporated into the learning system?

- **RQ2:** What are the usability criteria for the proposed learning system for a D/HH student?

  The hypothesis of this research is defined as:

- **[H0]:** An inclusive intelligent e-learning system will help deaf /hard of hearing students in a classroom setting improve their English reading and writing abilities.

Table 1.1: Research Objectives (O.B.) mapped to the Research Questions (R.Q.)

OBJECTIVE OF RESEARCH (O.B.)	RESEARCH QUESTION (R.Q.)
OB1: Identify an effective way to improve the English abilities of D/HH students.	**RQ1:** What features can be incorporated into the learning system?
OB2: Build a system that incorporates existing technologies that will support the classroom experience of D/HH students, i.e., to access course materials, participate in class discussions, and attend an in-person class.	**RQ2:** What are the usability criteria for the proposed learning system for a D/HH student?
OB3: Identify a set of mechanisms and structures which will serve as policy recommendations that tertiary institutions in Ghana can use to support inclusive education for D/HH persons.	**RQ1:** What features can be incorporated into the learning system?
OB4: Identify the problems that affect and	**RQ2:** What are the usability criteria for the

limit persons with disabilities from accessing tertiary education.	proposed learning system for a D/HH student?

Chapter 2: Literature Review

2.1 Overview of Assistive technologies for Deaf/Hard of Hearing

The use of technological devices in classrooms provides multiple means of participation for all children in all aspects of learning and assessment [8]. Education Technology (EdTech) is a digitally powered accessible technology, assistive technology, and general-purpose technology used by children with disabilities for learning [28]. Assistive technologies enable individuals with disabilities to perform functions that might otherwise be difficult or impossible [1]. Hearing assistive technology helps individuals with hearing needs in listening, comprehending, or recognizing sounds and enhancing sound frequencies, making them much clearer [7]. Devices like Hearing aids, Cochlear implants, F.M. systems, Infrared systems, and loop systems are examples of hearing assistive tools [7]. In addition to hearing assistive devices, other Information and Communication Technology tools like websites, mobile applications, speech-to-text algorithms, and others are combined to enhance the classroom experience of a D/HH student.

2.1.1 Literature Analysis

Several researchers have carried out case studies, experiments, and analyses on the use of I.C.T. tools, assistive technologies to promote an inclusive classroom experience of D/HH across educational levels – primary, secondary, and university. Some of these research papers have been highlighted to gain insights from them and identify limitations in their approaches. The table below (Table 1.2) shows a comparison of 10 academic research papers across the world on the education of D/HH students based on the following criteria:

- Research methodology
- Disability foci
- Physical/infrastructural support for persons with hearing impairment, and
- Technological support for persons with hearing impairment.
- System type

Table 2.1: Comparative analysis of several pieces of literature that outline interventions made across the world to support an inclusive education of persons with D/HH

FOCUS	AUTHOR(S)	RESEARCH METHODOLOGY	DISABILITY FOCI	INFRASTRUCTURE SUPPORT FOR HI	TECHNOLOGICAL SUPPORT FOR HISs	SYSTEM TYPE
To understand how D/HH students can participate in an inclusive classroom with deaf students	Khalid N. (2018)	*Semi-structured interviews * Classroom observation *Ethnographic design	D/HH in elementary school	*Classroom setting *Small focus group discussions *One Lecturer	*Sign language interpreter	

It explored the benefits of sign-language interpreting and text alternatives for D/HH students in a classroom	Marc, M. et al., (2006)	Experiment	D/HH in tertiary level	*Two Faculty, *Speech to text algorithms, *Interpreters,	*Text-to speech algorithms placed in a computer system	Desktop

Table 1.2: Comparative analysis cont'd

FOCUS	AUTHOR(S)	RESEARCH METHODOLOGY	DISABILITY FOCI	INFRASTRUCTURE SUPPORT FOR HI	TECHNOLOGICAL SUPPORT FOR HISs	SYSTEM TYPE
Higher education For Deaf/Hearing Impaired (D/HI) students	Lang H.G. (2002)	Analysis of other existing literature	Deaf/Hearing Impaired students	*Faculty *Inclusive classroom	*Text-to-speech *Sign language interpreting	Desktop for text to Speech algorithm
It describes a centralized learning plat-form to enable inclusive interactivity in	Khwaldeh, s. et al. (2007)	*Research of existing Problems faced by D/HH students. *System development *User testing	Deaf/Hearing impaired	Classroom, E-learning platform	Web-based app-plication, with virtual chat rooms and other functionalities	Website

				the classroom between Deaf students and the teachers.

Table 1.2: Comparative analysis cont'd

FOCUS	AUTHOR(S)	RESEARCH METHODOLOGY	DISABILITY FOCI	INFRASTRUCTURE SUPPORT FOR HI	TECHNOLOGICAL SUPPORT FOR HISs	SYSTEM TYPE
The research introduces a new courseware interface design based on user requirements for students who have a hearing problem	Saud, F. et al., (2016)	*Qualitative research, *Interviews	Deaf/Hearing impaired	Teacher, Courseware Management System	Storyboarding, visuals were used to inform the development of the E-learning platform	Desktop
The study was to determine the efficacy of	Nation, S.et al., (2014)	Experiment, interviews, and observation interviews, and obser	Deaf/Hearing impaired	Inclusive classroom, software systems	Speech to text algorithms	Software

	vation		
speech-to-text			
software			

Table 1.2: Comparative analysis cont'd

FOCUS	AUTHOR	RESEARCH METHODOLOGY	DISABILITY FOCI	INFRASTRUCTURE SUPPORT FOR D/HH	TECHNOLOGICAL SUPPORT FOR D/HH	SYSTEM TYPE
It focused on speech-to-text technology by assessing the accuracy of -Captions used in the system -Quality of lecture	Millett, P (2020)	Analysis of software programs	Deaf/Hearing impaired	*Inclusive classroom technologies	Speech to text algorithms, websites, mobile apps	Mobile, and desktop

Table 1.2: Comparative analysis cont'd

FOCUS	AUTHORS	RESEARCH METHODOLOGY	DISABILITY FOCI	INFRASTRUCTURE SUPPORT FOR D/HH	TECHNOLOGICAL SUPPORT FOR D/HH	SYSTEM TYPE
The authors wanted to examine the effects of captions on D/HH students' comprehension abilities	Yoon, J.O, Kim M. (2011)	*Experiment, case study with some participants *Observation *Focus group discussion	Deaf	An experiment in an inclusive classroom through an experiment and control group	Captions and subtitles from different mobile devices	Mobile, Website

FOCUS	AUTHORS	RESEARCH METHODOLOGY	DISABILITY FOCI	INFRASTRUCTURE SUPPORT FOR D/HH	TECHNOLOGICAL SUPPORT FOR D/HH	SYSTEM TYPE
The authors presented this paper to evaluate the efficiency of such learning source/ instructional websites according to technical criteria	Bayati, M.A. et al.(2013)	Evaluation of instructional Websites for D/HH	Deaf/Hearing impaired	Evaluation and criteria analysis	Website contents, technical criteria of websites	Website

2.2 Analysis of Literature that Promotes Inclusive Education for D/HH

Research articles have revealed that many D/HH students experience difficulties participating and interacting in a classroom setting with teachers and hearing peers [22]. A case study in Saudi Arabia [3] revealed some of the challenges faced when using manual methods of sign language interpreters in an inclusive classroom for Deaf students. The challenges discussed include - limited experience of the sign interpreters and the lack of collaboration between teachers and sign interpreters.

Another paper [3] indicated some of the possible factors that might limit the participation and interaction of D/HH students in an inclusive classroom and they are: communication barriers, teachers' attitudes that prevent inclusive participation, and limited knowledge about inclusion and disabilities, low awareness about deafness from the hearing students, and poor classroom organization.

Additionally, lecturers have a role to play in enforcing inclusive education. In one of the South African universities, research showed that the D/HH students complain of teaching practices at the university not being inclusive, and lecturers do not make efforts to assist the D/HH during class lectures [11].

To promote the maximum participation of deaf students in an inclusive classroom, some researchers have identified other alternative technologies to sign language interpreters and they include: Speech to text applications; Mobile/Web design technologies; and Captions/Subtitles technologies. These alternatives will be discussed further in the sections below.

2.2.1 Speech-to-text Applications

In a typical African college or university classroom setting, students take up to five (5)

or more courses and encounter lecturers with different teaching and communication styles. Sometimes, instructors refer to multimedia resources like YouTube videos, making it more difficult for a D/HH to understand what is being taught if they must depend on sign language interpreters [25]. Therefore, an inclusive classroom to support D/HH requires the use of real-time captioning using a Computer Assisted Real-time Translation (CART) captioner. A captioner (either a person or through a system) is usually present during class and produces an exact transcript of everything heard in the classroom in real-time [25]. CART requires the use of a good microphone in the classroom so that the captioner can listen to the lecturer's voice and transcribe accurately. However, one limitation to the development of captioning system is in its ability to recognize and transcribe multiple voices in a classroom discussion where the students do not have individual microphones [25].

Another potential issue identified under captioning technology is the issue of accuracy which is identified by the total number of errors in a transcript. Some mistakes in captioning systems include spelling errors, omissions, additions, substitutions, and phonetic errors. However, apart from the CART technology, are other examples of other Speech-to-text software in modern day include Google's Google Voice; Nuance's Jott and Dragon Dictation; Crescendo Systems' Crescendo Speech Processing; Nuance's Dragon Naturally Speaking; me2me's Frisbee; Spantel's T.S.P.; and MacSpeech Dictate [18]. These applications have global usage as they are used by both D/HH and hearing individuals in large organizations that deal with large audio files [24].

2.2.2. Captions/Subtitles

Another way that D/HI can participate in classroom experience is through Captions. In

their research, researchers [38] discovered the benefit of using captions to support D/HI learning. The researchers highlighted that text-best caption provides D/HH students access to verbal information. For instance, educational videos with captions can impact the comprehension ability of Deaf students' content comprehension, reading comprehension, and learning ability/interest [38]. However, one challenge of using captions is in its inability to consider the reading skills of the D/HH students. Thus, D/HH students who have low reading skills will have trouble understanding captions than D/HH students with high reading skills [38]. Those with low reading skills can be supported through a captioning system or through Machine learning, speech to text application that can effectively interpret the audio from a video ranging from complex to simple English vocabularies or terms.

2.2.3 Mobile/Web Design Platform

Researchers have proved that E-learning systems in the form of mobile and or web platforms can support the classroom experience of D/HH. An E-learning system courseware was implemented in Malaysia for D/HH between 7 to 8 years old who wanted to learn alphabets and words using text and sign language [30]. The researcher designed the system using storyboards to describe the customer journey when using the system. They incorporated various sections to help guide the system's users and measured it with different HCI system principles such as consistent color-coding, accuracy, and performance. After development, the researchers tested the system with the targeted D/HH users.

Furthermore, a researcher [25] identified two mobile apps that can facilitate small group conversation between D/HH and non-hearing-impaired students in a classroom setting. They are known as Ava and Microsoft Translator. Microsoft Translator is a web-based app developed

for language translation, and it provides captioning when the translation is set to "English-to-English." When the user logs in, they can view a "chat room" interface which allows two or more users to engage in a conversation [25]. A speaker using Microsoft Translator will have to press and hold an icon while talking, and it can be used in a small group situation where speakers touch the icon when they want to speak and release it when they are finished talking. Ava also allows multiple users to log in to a chat room interface, and the app then provides real-time captioning of each user's voice [25].

Another case study in Japan demonstrated how a centralized-based learning e-system increased interactivity between the teachers and D/HI students. The researcher who developed the system followed a set of guidelines which include: - Visually offer audio information, -Subtitles for each video, picture, and text, -A dictionary and glossary of terms, -Attractive and practical graphical user interface (G.U.I.) for users, -Effective approach to navigating inside the learning material, -Difficulty levels for assessments, -Structured presentation of the e-learning material in an understandable format [19].

Chapter 3: Methodology

In conducting research with various stakeholders in the disability space in Ghana, a few of the research methodologies identified in Table 3, were used to gain insights into Disability Education in Ghana.

3.0 Overview of Methodological Approaches

The methodological approaches used include:

- IRB forms

- Online survey

- Focus group interviews

- System Performance

- Usability metrics

3.0.1 IRB Forms

Before beginning the research process and interaction with various stakeholders, the Institutional Review Board (IRB) of Ashesi in charge of reviewing research activities ensured that this thesis research met the standards of conducting research. This is in accordance with the international standards for the protection of human participants in academic research. The IRB clearance forms obtained were distributed and read to the participants before engaging with them.

The second and third methodological approach focuses on data collection carried out with various stakeholders in the disability sector.

3.0.2 Online Survey

An online survey was created and distributed to specific stakeholders and disability organizations in Ghana (see *Appendix C*). The survey included section with questions that should be answered by the following groups of people: *Students with disabilities or Parents or Guardians on behalf of persons with disabilities, School Administrators, and Ghanaian I.T. Industry Experts*. An online survey was created to gain more information from P.W.D. on some assistive technologies they use to carry out general and education-specific activities. The survey also targeted school administrators to find out how they promote an inclusive education of P.W.D. and non-disabled persons in their educational institutions. Additionally, the Ghanaian I.T. industries were included in this survey to identify what means they contribute to developing assistive technologies to cater to the P.W.D. The list of questions asked to the stakeholders can be found in the Appendix section.

3.0.3 Focus Group Interviews

In addition to the online survey/questionnaire, several focus group sessions were conducted to get qualitative data on the experiences of persons with disabilities. The approach used in the focus group interviews was to first ask for consent from the interviewees and assure them of the confidentiality of the information shared during the focus group session. The interviewees were given a list of questions during the interview, and their responses were recorded on paper which was translated into themes. There were two focus group discussions.

The first was with five (5) school administrators of a university that had implemented inclusive education for D/HI and non-deaf students. The entire session lasted for two hours. The second focus group had **47 participants**, where four identified as deaf students and 43 identified as H.I. students. The image of the consent form and interview question can be found

in *Appendix A & Appendix B,* respectively.

3.0.4 System Performance

This is to measure how efficiently a D/HH student can perform tasks on the system through the system functionalities. It will include aspects like task response time which measures how long a D/HH can complete a task efficiently.

3.0.5 Usability Metrics

The system will be evaluated using Human-Computer Interaction (HCI) principles such as simplicity, consistent color schemes, and free from errors.

3.1 Data Collection

Data was collected using primary research. Online surveys and questionnaires were sent to D/HH students and other stakeholders in the Disability space across Ghana. For this research, the identified stakeholders who took part in the online survey include (D/HH. students, Parents of D/HH, School Administrators involved in disability education, and I.T. industries that develop technologies to support D/HH students). The duration of collecting responses from the survey was two months. Additionally, one-on-one interviews and focus group conversations were conducted with D/HH students and other stakeholders in the disability space. The contact institutions used during the Primary research include The Special Needs Department at the University of Ghana Legon, and School of the Deaf, Mampong, Eastern Region.

Also, data was gotten from private independent researchers who interviewed a group of persons with disabilities in Ghana. The findings from this research are found in Table 1 of Chapter 1 which provided more insights into the challenges faced by P.W.D in Ghana.

3.2 Data Sampling

During the primary research, data sampling and the sample size were determined based on the availability of D/HH participants and other stakeholders. The major challenge faced was getting respondents and participants for both the online survey and focus group discussions. A breakdown of the total sample size involved in this research is as follows:

The **online questionnaire** and **survey** had **21** Responses.

The Focus Group interviews were held with students and other disability stakeholders in three locations.

Group 1: Church of Christ

Deaf and Hearing Impaired - 47

Deaf/Hard of Hearing - 4

Group 2. Office of Students with Special Needs, University of Ghana, Legon

School Administrators – 5

Group 3: School of the Blind, Mampong Eastern Region

School Administrator - 1

Deaf/Hearing Impaired students - 20

Teachers - 3

3.3 Discussion of the Data from Online Survey/Questionnaire

The total number of respondents from the online survey was 21, and the survey was partitioned into three sections

-Persons with disabilities (SECTION 2),

-Parents/Guardians on behalf of persons with disabilities (SECTION 2),

-School/University administrators (SECTION 3), and

-Ghanaian I.T. Industry (SECTION 4)

From the online survey questions, these statistics were obtained from the respondents' responses.

The first question shown in Figure 1.0, which asked the respondents to identify *their roles*, had 20 respondents where the highest category of respondents were the students:
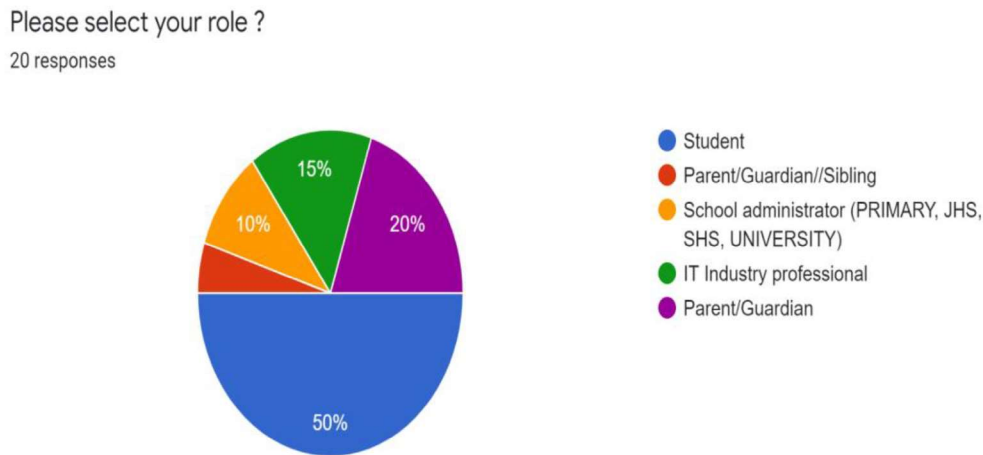

Please select your role ?
20 responses

- ● Student
- ● Parent/Guardian//Sibling
- ● School administrator (PRIMARY, JHS, SHS, UNIVERSITY)
- ● IT Industry professional
- ● Parent/Guardian

Fig 3.0: Description of the role of the participants involved in the research

Statistics from Section 2 of an online survey

This section had 16 respondents. Firstly, when respondents identified their gender, we had more male respondents than female respondents in the online survey.

Table 3.1 Gender category

Male	**70%**
Female	**30%**

Secondly, the respondents were asked to identify their disability type, and 50% stated that they were either Deaf or were Hearing impaired, and 12.5% were Hearing impaired, which means that they are

not entirely deaf in some cases.

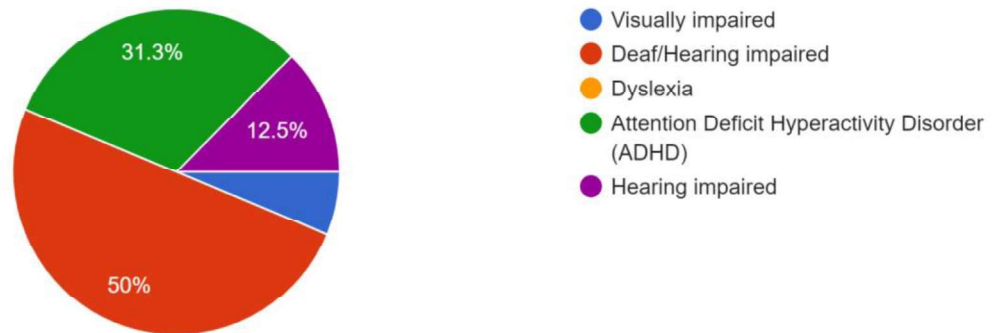**If yes, what disability do you have?**
16 responses

Fig 3.1: Identification of the disability type

Thirdly, most respondents (80%) were either tertiary students or stakeholders within the tertiary university space. This is because the available audience were people in the tertiary universities and those who worked within the Ghana Disability Space.

What is your level of education? i.e (JHS 1-3, SHS 1-3, University)
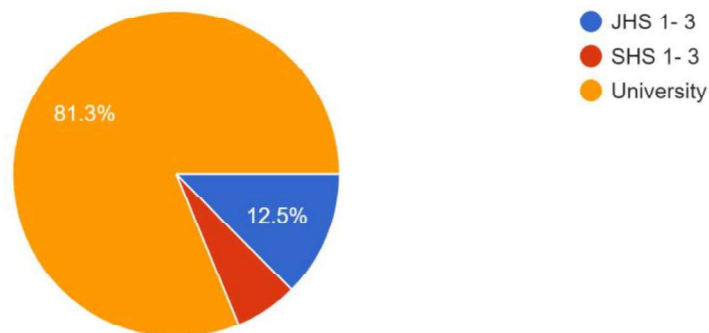16 responses

Fig 3.2: Indication of level of education of respondents

Fourthly, many of them (~ 44%) stated that their disabilities resulted from sickness, while only 25% of respondents had the disability from birth.

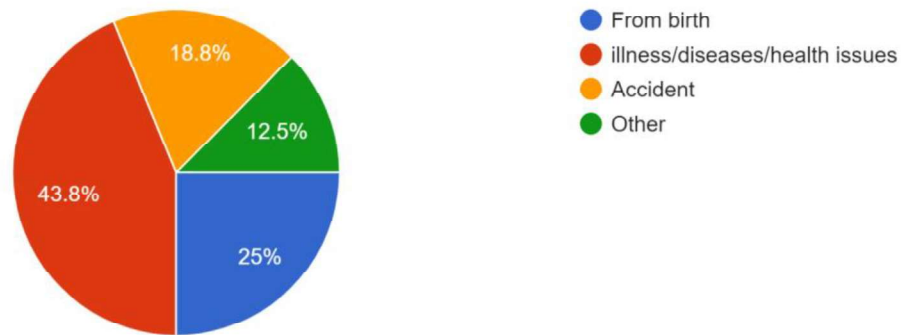What is the origin of your indicated disability?
16 responses

Fig 3.3: Indication of origin of the disability

Online survey statistics: Parents/Guardians on Behalf of Persons with Disabilities

We had a few Parents/Guardians who stated that they homeschooled a person with a disability using various technologies like *Sign Language applications* which is the common one. However, many of the parents said they did not homeschool their children with disabilities.

If you are a parent or guardian or sibling, are you homeschooling your child or ward?
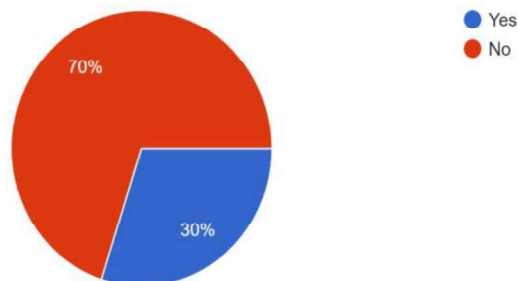10 responses

Fig 3.4: Indication if a Parent/Guardian homeschools their children with disabilities

They mentioned a few features that they would need to support the educational journey of persons with disabilities.

Question asked: *Would you want to use technological applications in your educational journey? Why? Mention some features you would like to see in the application.*

The table below shows the responses to the question asked above.

Respondents: **12**

Table 3.2: Respondents suggested features for proposed system

Yes. A magnifier and something to bolden text.
To help improve the mental capacity of the child.
An electronic application that can convert Speech- to text enables the deaf and hard of hearing to get instructions with minimal effort.
Remote video interpretation
It is cheaper and more accurate
They make us know what we learn better
This gives me the ability to understand in class
Yes, how about something like when a hearing person is talking to someone who's deaf, and whatever they say will pop up on the app's screen? That would be cool. We would be able to catch up with the lecturers and our hearing colleagues.
Yes, a live translator APP.
Speaking to transaction sign language

> Yes, because it will help me teach.

From the table above, the **bolded** and **italicized** text are features suggested by the respondents and would guide the development of the E-learning system for D/HH students.

Online survey statistics - School Administrators

One institution participated in the online survey- the University of Education, Winneba. They identified that they mostly use sign language and text-to-speech, which indicates that very few institutions have explored Speech to text applications. However, efficient speech-to-text technology can be adopted across Ghanaian tertiary institutions to support D/HH students.

Online survey statistics - Ghanaian IT Industry

We had three companies in Ghana - Ecobank Ghana Limited, Volta Deaf, and TheInterpreterGh, that participated in the online survey. These companies indicated that existing technologies such as Google assistant, laptops, and phones can be used to teach disabled students in Ghanaian universities. All three companies indicated their desire to collaborate with students from Ashesi to develop technologies to support P.W.D.

3.4 Discussion of the Insights from Focus Group Discussions

Group 1 - Church of Christ, Nsawam Road - Circle

We had 47 participants who identified as Deaf/Hearing Impaired students during this focus group discussion. This discussion was conducted using three sign language interpreters (one being an Ashesi student, and the remaining were from the church). A set of interview questions (see *Appendix A*) were asked to the participants through the sign language interpreters who in turn relayed the participants' responses to the research team. During the focus group

discussion, the research team took notes of the participant's responses. They all stated that their primary means of communication with their peers and other hearing colleagues is sign language.

The insights gotten from the discussion include:

- The participants rely entirely on sign language in communication and are not conversant with Speech-to-text applications.

- Feel safe and accepted in the church community due to measures instituted to accommodate them and their special needs.

Group 2 - Office of Special Needs, University of Ghana, Legon

This group consisted of five school Administrators. The Capstone research team could not meet with any D/HH students because they students were on vacation at the time of the research. The school Administrators provided insightful information on the state of disability education in the university, the perception of P.W.D. in Ghana, and the struggles faced by P.W.D.

The insights gotten from this group include:

- Many Deaf students depend on Mobile applications since it is easier and more convenient to use.

- Most of them use other technologies such as speech-to-text applications during classes and are highly encouraged to sit in the front rows of the class.

- The institution uses manual methods such as a sign language interpreter and a note taker and technological devices such as particular laptops with tools during the exams.

Group 3 -School of the Blind, Mampong

This group consisted of **20** Deaf/Hard of Hearing in high school, three teachers, and one

school administrator. Two teachers and a member of the Capstone Research team administered the focus group discussion question using sign language. The participants wrote their responses on sheets of paper given to them at the start of the discussion.

After meeting with the participants for 1 hour, the teachers and the school Administrator were also interviewed.

Some of the keynotes drawn from the discussion include:

- The students are brilliant and good at math and science subjects that require thinking. However, most of them they face challenges in their English courses which affects their ability to meet entry level requirements for tertiary institutions in Ghana.

- The students get admitted into universities, go to training colleges, or start their businesses by doing informal jobs across the country after their education at Mampong.

- It was also noted that many Deaf students in Ghana are not given a chance to pursue science-related courses/majors at the university level and are regularly pushed to social science courses when they get admitted into a public university.

Observational insights made during the discussion include:

- A few of them became Deaf at specific points in their lives for instance during teenage years or early childhood. These categories of Deaf students were able to speak and make sound, although they did not understand what they were saying.

- Most of the participants could write and express themselves due to being in an educational environment. However, they had issues with spellings caused by their use of sign language, where not all tenses can be represented using a sign demonstration.

Chapter 4: Implementation

4.1 System Architecture

The insights derived from the primary research informed the design of the system to support the educational needs of the D/HH in a Ghanaian tertiary institution. Some of the suggested features given by the participants of the focus group session and online survey include:

- The system should have a speech-to-text application to help the Deaf students hear the lecturer and other hearing colleagues.

- The text should be magnified.

- The system should be laptop and mobile compatible because most D/HH students mostly use mobile applications.

Based on the features mentioned, the proposed system is *an Intelligent and E-learning web application* that allows a D/HH:

- Enroll in a course

- Access course materials

- Attend an in-person class, or view course recordings with the help of a speech to text transcriber that takes the lecturer's audio or audio from a video and translates it to text.

Then, the transcribed text is displayed on the student screen, which can be saved in any known document extension such as .pdf, and .doc format. On the other end of the system, the lecturer can login as an Administrator to monitor the student's login activities and upload course materials.

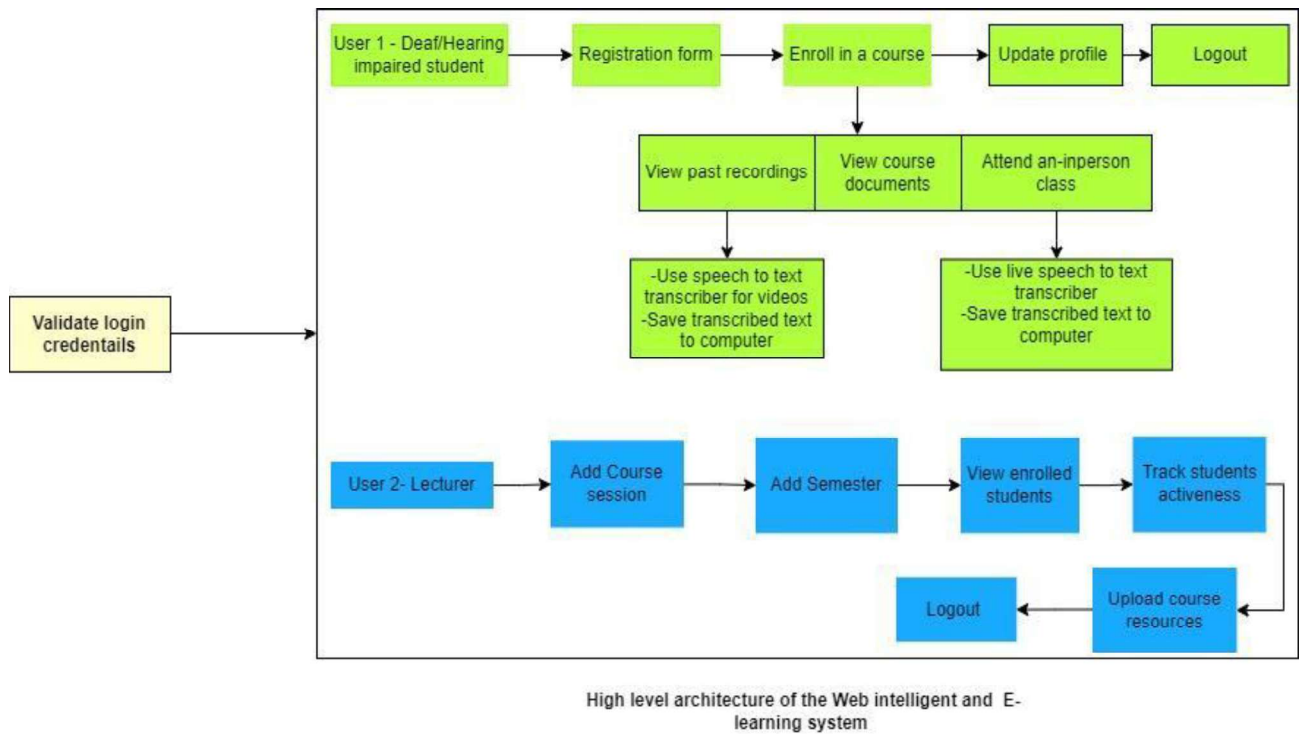The system architecture is displayed in *Figure 4.0* below:

Fig 4.0: Architecture of An Intelligent and E-learning system for D/HH in a Ghanaian University.

4.2 Implementation Tools

The system was developed using a technology stack (Figure 4.1) consisting of some programming languages and google cloud speech APIs.
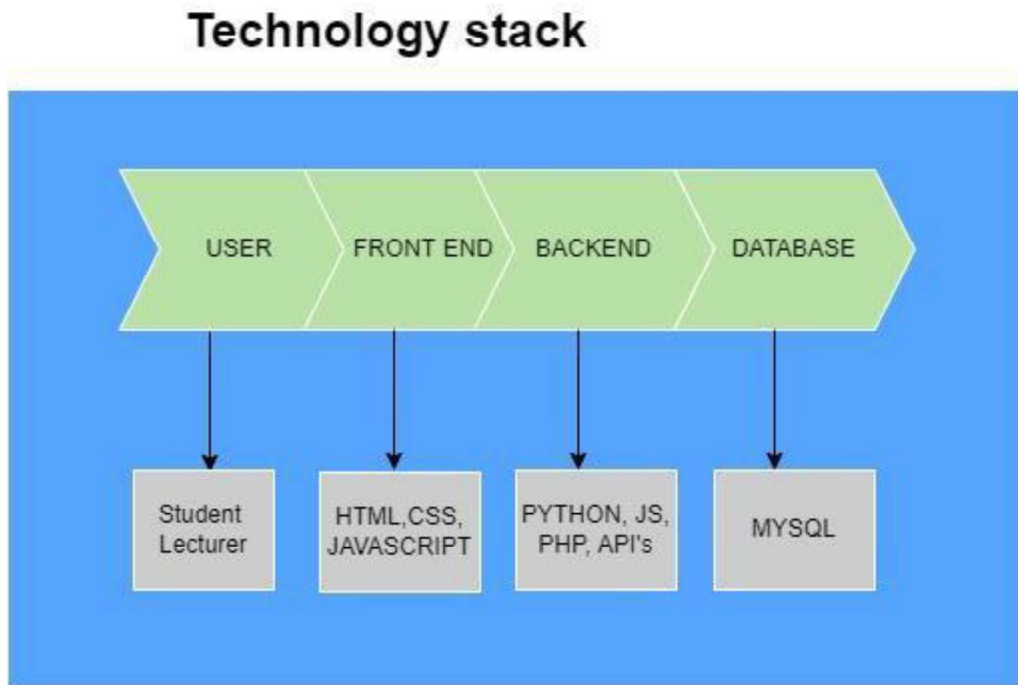

Fig 4.1: E-learning system technology stack

4.3 Functional and Non-Functional requirements

4.3.1 Functional Requirements

- **FR01**: The system should display transcribed text to the user through its Transcriber functionality

- **FR02:** The system should have proper labels through its Menu Bars and user interface which should guide the users of the system

- **FR03:** The system should display course materials and resources for easy accessibility for D/HH students

4.3.2 Non- Functional Requirements

- **NR01**: The system should be fast and responsive when the user clicks different pages on the website.

- **NR02**: The transcription functionality should be accurate and efficient to enable the D/HI to understand what is said in class or in a video recording.

- **NR03**: The system should be secure and prevent unauthorized access.

- **NR04**: The system's functionalities should be robust to accommodate either a D/HH student or a lecturer.

Using the defined functional and non-functional requirements, Layered architecture of the developed system is seen below in *Figure 4.2*

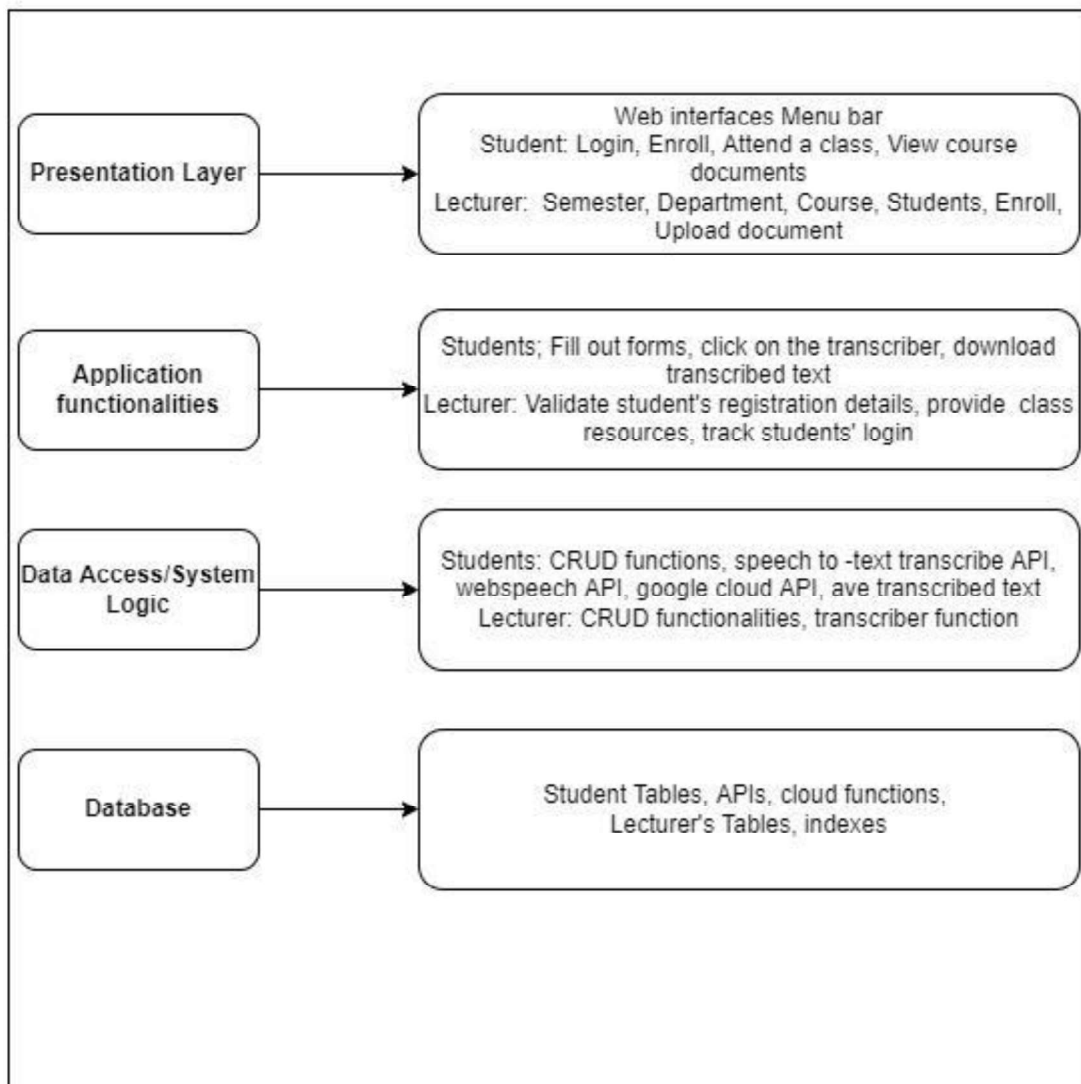# Layered Architecture for Intelligent E-learning System

Presentation Layer	Web interfaces Menu bar Student: Login, Enroll, Attend a class, View course documents Lecturer: Semester, Department, Course, Students, Enroll, Upload document
Application functionalities	Students; Fill out forms, click on the transcriber, download transcribed text Lecturer: Validate student's registration details, provide class resources, track students' login
Data Access/System Logic	Students: CRUD functions, speech to -text transcribe API, webspeech API, google cloud API, ave transcribed text Lecturer: CRUD functionalities, transcriber function
Database	Student Tables, APIs, cloud functions, Lecturer's Tables, indexes

Fig 4.2: Layered architecture of an E-learning system

4.4 System Diagrams

The E-learning system is implemented into two parts. One part caters for the needs of the D/HH student, and the other part is managed by the lecturer. The MVC architecture of the system is shown below:

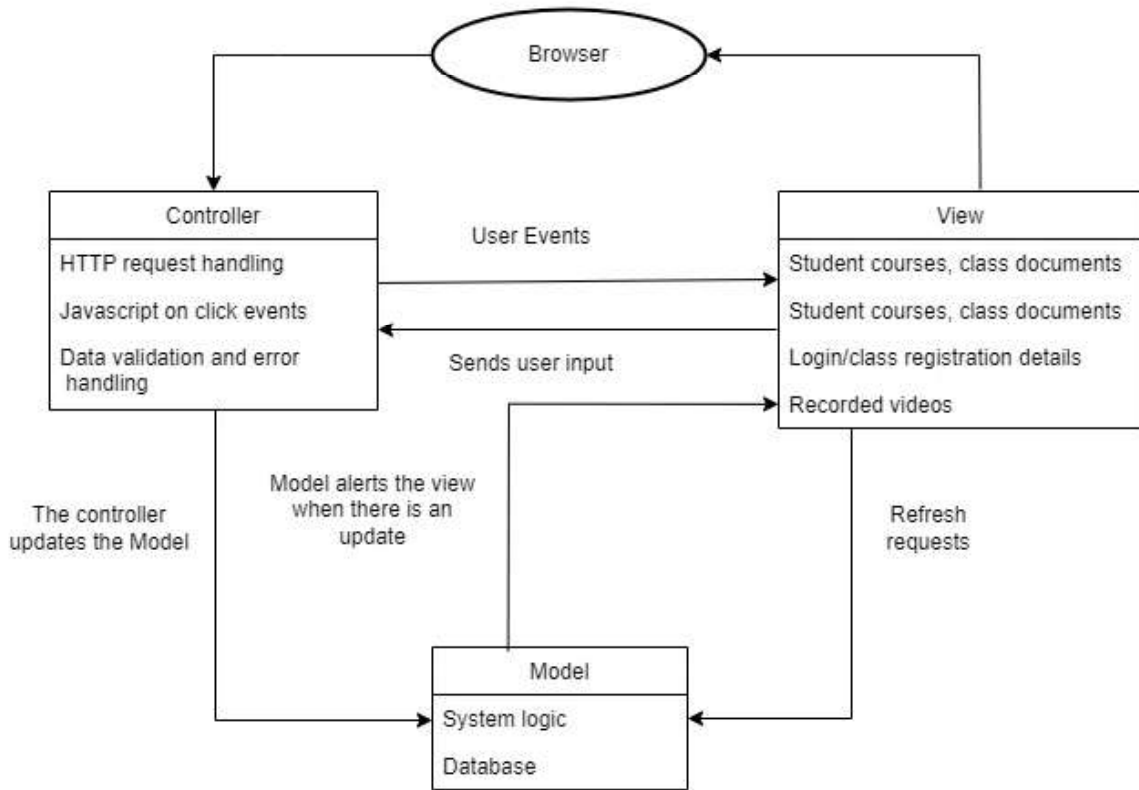*Fig 4.3: MVC architecture of an E-learning system (student view)*

MVC ARCHITECTURE FOR INTELLIGENT E-LEARNING SYSTEM (LECTURER VIEW)

Browser

Controller
HTTP request handling
Javascript on click events
Data validation and error handling

User Events

Sends user input

View
Login
Upload recorded videos
View registered students

The controller updates the Model

Model alerts the view when there is an update

Refresh requests

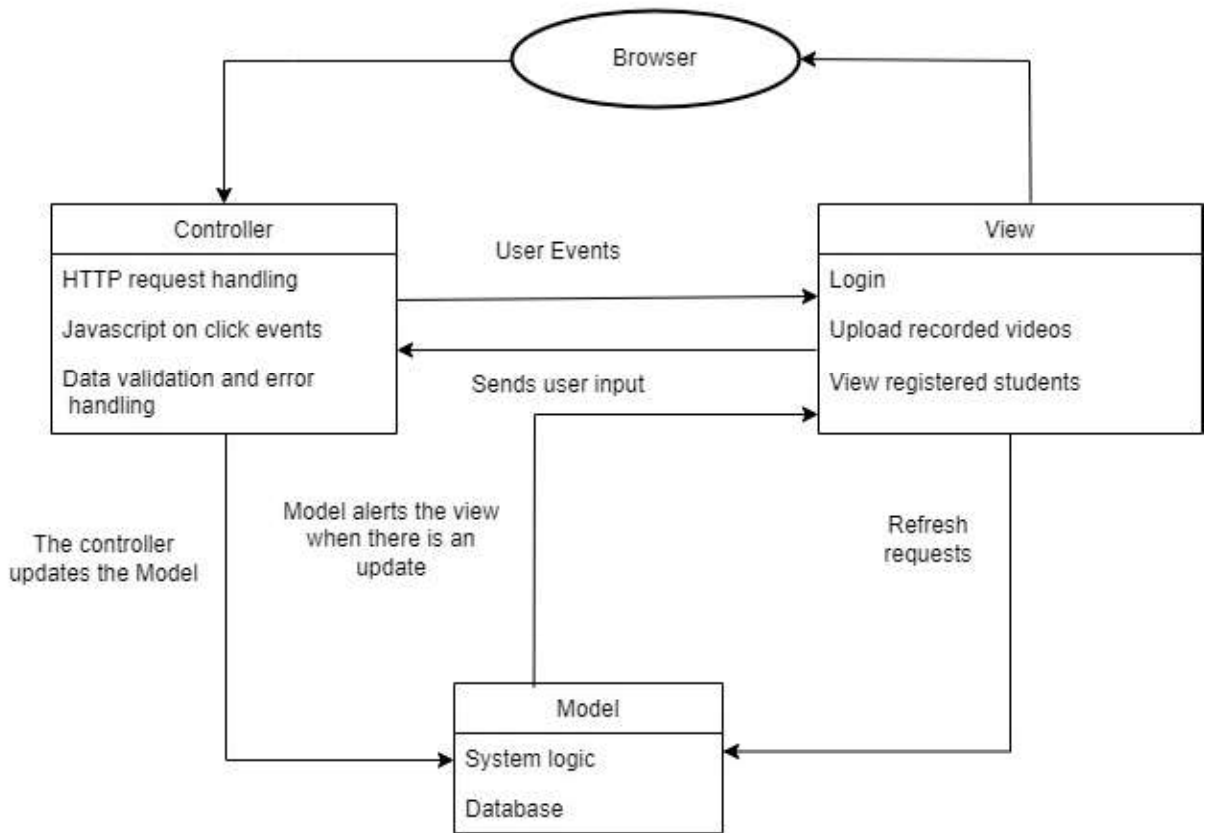| Model |
|---|
| System logic |
| Database |

Fig 4.4: MVC architecture of an E-learning system (Lecturer view)

Next, a diagrammatic representation of the student and lecturer journey interacting with the system is shown in Fig 4.5.

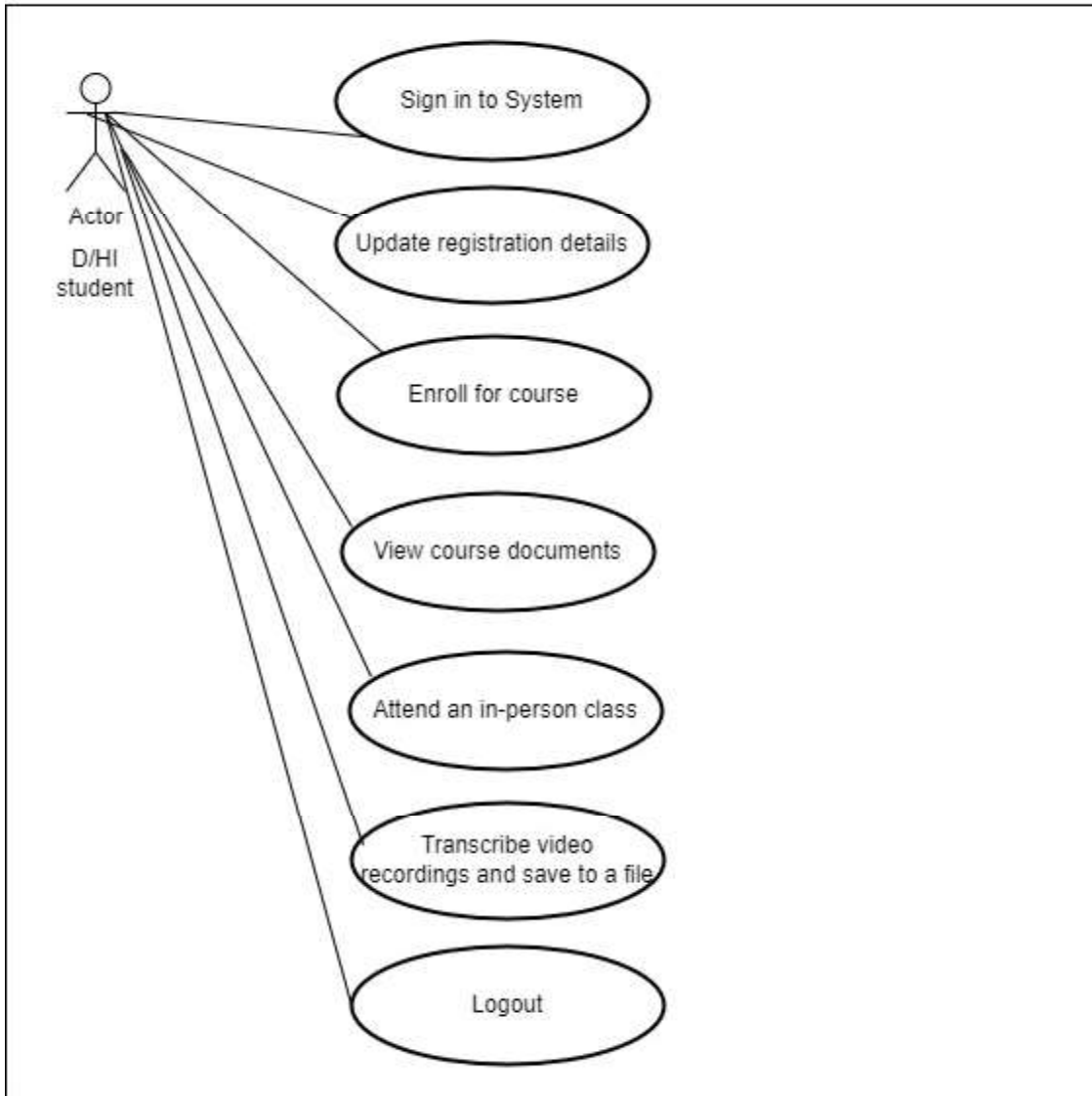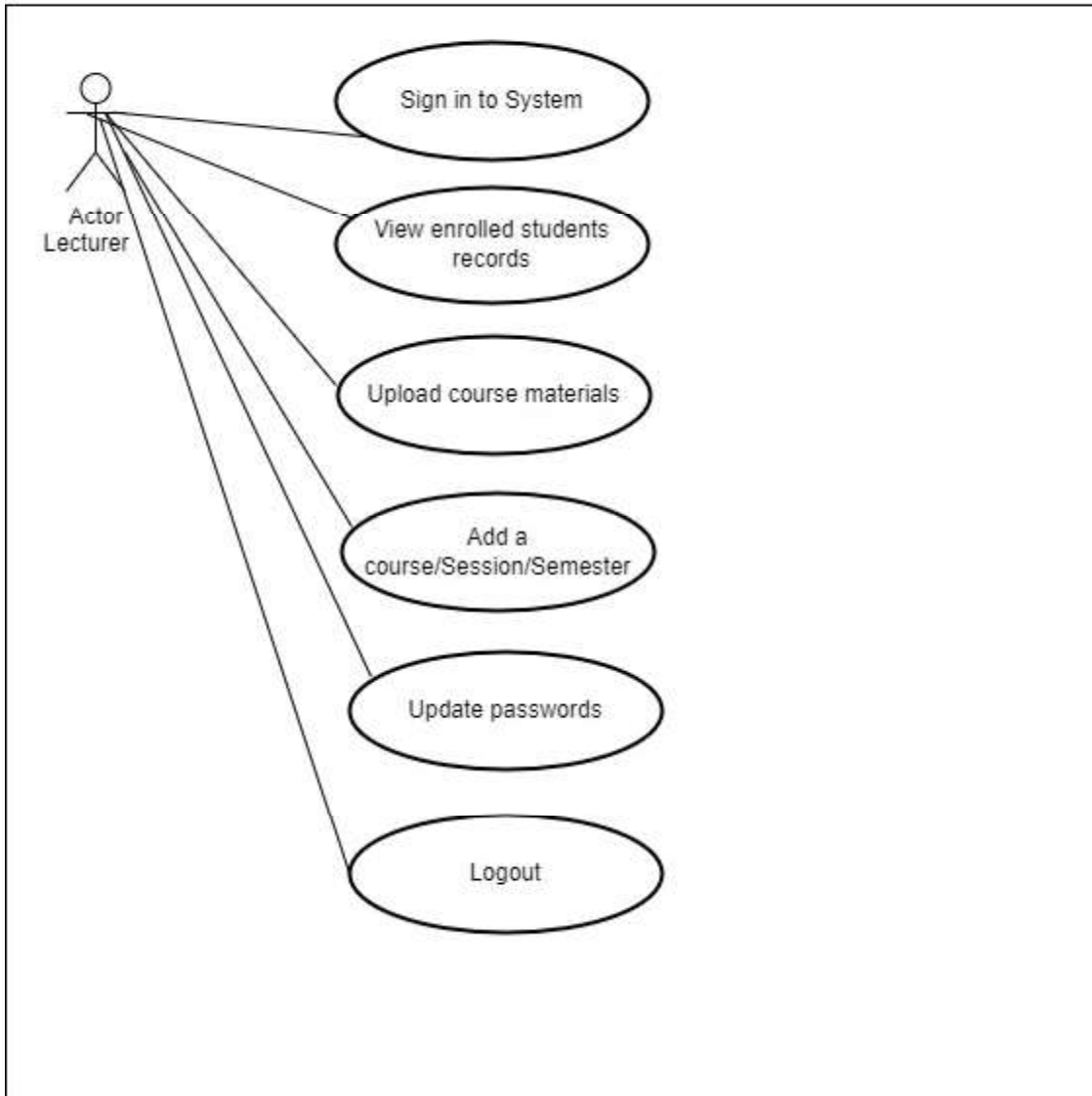*Fig 4.5: D/HH interaction journey with the E-learning system*

Fig 4.6: Lecturer interaction journey with the E-learning system

4.5 Implementation Process

The E-learning system developed follows the three-tier architecture of Frontend, Backend, and Database. The system was developed to be mobile phone compatible so that D/HH can access the site on their mobile phones.

4.5.1 Front-end

The front-end design of the system for both the lecturer and student was implemented using HTML, CSS (Cascading Style Sheet), J.S., and Bootstrap which is the foundation of many web pages, and they can effectively be used to capture the highlighted features. The landing pages of the website can be seen in Fig 4.7
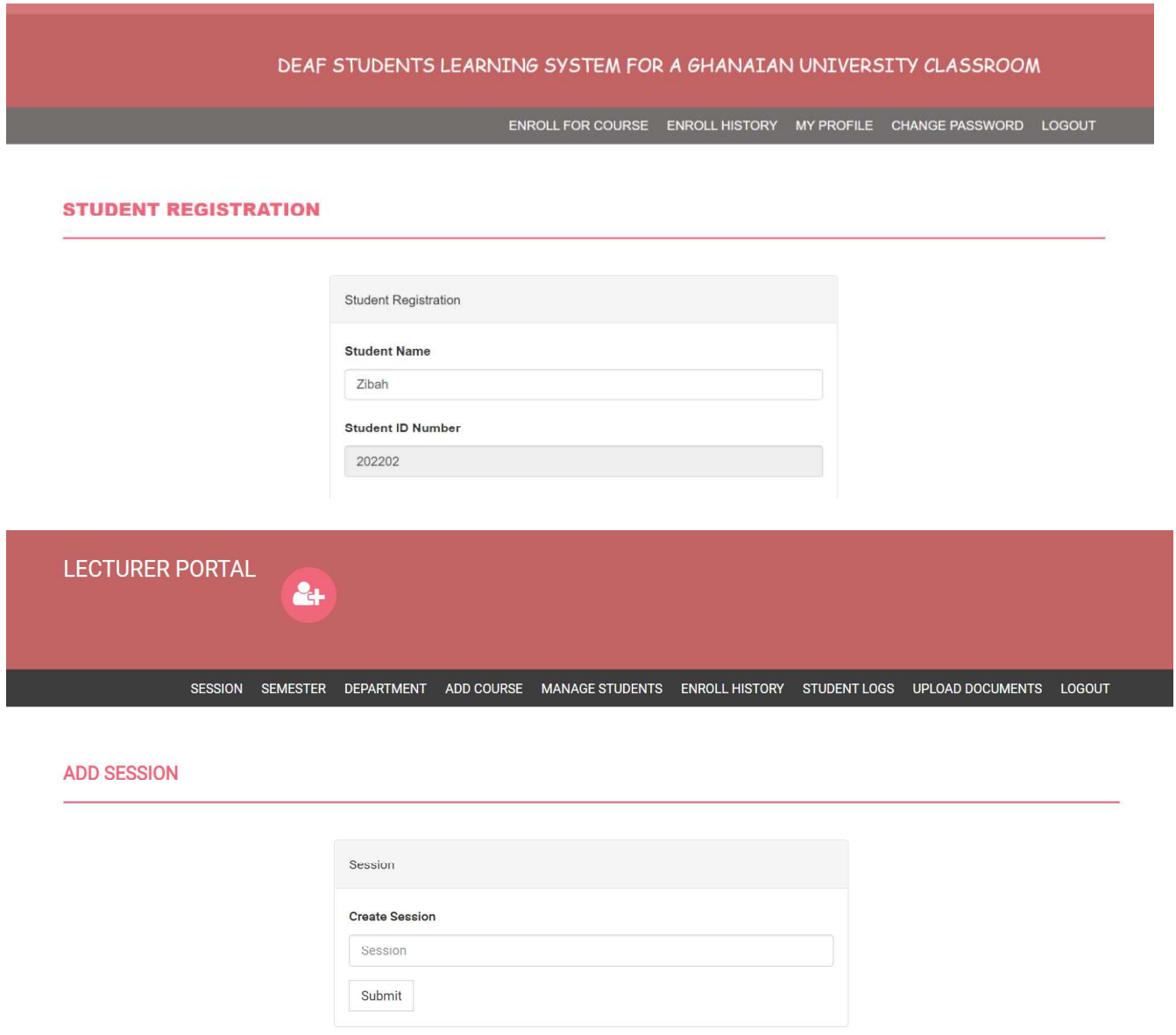

Fig 4.7: Index page for the student/lecturer

4.5.2 Back-end

The programming languages JavaScript, PHP, and Python were combined to implement the functionalities of the system. For instance, JavaScript was used to implement the action behind every button click from the front-end pages. PHP was used to fetch data from the database and validate user's input that was to be inserted into the database. PHP and J.S. were also used to validate the user's input and handle wrong inputs by displaying an error. Python was used to implement the google cloud speech-to-text functionality which was displayed on a web page using Python's FastAPI.

4.5.3 Database

This database used for the system is developed in SQL format (Structured Query Format). SQL was chosen over NoSQL due to the relational nature of the tables where a table can have multiple relationships with other tables i.e. (*Parent table-Child table relationship).* Also, SQL is better suited because the data we are storing from the student and lecturer must be consistent and highly structured.

4.6 System Features

The system functionalities developed is based on the suggestions and insights gotten during the interview process with Deaf students and School Administrators. This system serves a proof of concept to ascertain if the features included can effectively support an inclusive education for Deaf/Hard of Hearing students in a Ghanaian tertiary university. The features developed in the system will be described in detail below.

4.6.1 Transcription Functionality

On the student part of the website, the Speech-to-text feature is the core functionality to

support Deaf/Hard of Hearing students in a live class and this was implemented using two approaches. The first approach was developed using Google cloud speech API, and the transcriber function built in python. The second approach was developed using Web Speech API in JavaScript, which interfaces easily with Google chrome browser. A detailed description of both approaches is found below.

4.6.1i First Transcription Approach using Google Cloud Speech API

The transcription code developed is written in python's functional programming style and transcribes from speech to text in real-time. Several modules and libraries from Google Cloud API and native python packages are imported into a python script. It works by taking streams of inputs as chunks using the stream module, which is stored in a temporary buffer.

The streaming audio is processed by a function that accesses the microphone from the user's machine and captures the voice of the user speaking into the microphone as a stream of audio input. Then, it calculates the difference between the first and last stream of audio input, which is stored in a queue data structure. The audio stream is captured and sent to Google Cloud Speech API, where the conversion is done from speech to text in real time. Once the audio stream has been transcribed into the text, it displays on the terminal of the users' machine. The transcribed text is displayed on a web page using Python's FastAPI.

The FastAPI is a web framework developed in python and is used to create Rest APIs which supports websites running with HTTP (Hypertext Transfer Protocol) functionalities like GET, POST requests. In this case, an instance of the FastAPI is created and the GET request is used to retrieve data which in this case is the transcribed data. A specific route called 'speak' is defined for the transcriber functionality and when the route is called, displays the transcribed text in Json format on the web page.

4.6.1ii Second Transcription Approach using Web Speech API

To measure how effectively Speech to text API's can support the inclusive education of D/HH student in a classroom setting, another speech-to-text API, web speech API which is supported by Google Chrome version 25 browsers and later. The Web Speech API was used to model the transcriber functionality and it was developed using JavaScript.

How the Web Speech API works

The webkitSpeechRecognition object is created and once created, it provides the speech interface and can set some of its attributes supported by Chrome browsers. For instance, the language attribute, 'Langs,' is set as 'En-US' meaning US English and this was done because the English is the standard of teaching in Ghanaian universities. Apart from the ''Lang' attribute, other needed attributes like punctuation were enabled. Next, the recognition.start() event activates the speech recognizer which enables it to capture audio from the speaker and specific event handlers are called to handle the converted text and display unto the web page. From the front-end design of the website, the user interacts with the transcriber functionality in two scenarios described below:

Scenario 1:

The student can use the transcriber when they want to attend an in-person live class when the lecturer is teaching. As the student is logged into the system, when they click *the attend class* button (Figure 4.8), they are directed to the page where they can turn on their microphone to record the lecturer's sound. At the end of the transcription stream, the student can save the transcribed text as a .doc or .txt format. The image below shows the specific button on the system that the student can click on.

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Fig 4.8: The student can click on the attend a class button

After the button is clicked, the system loads the page with the transcription feature as seen in
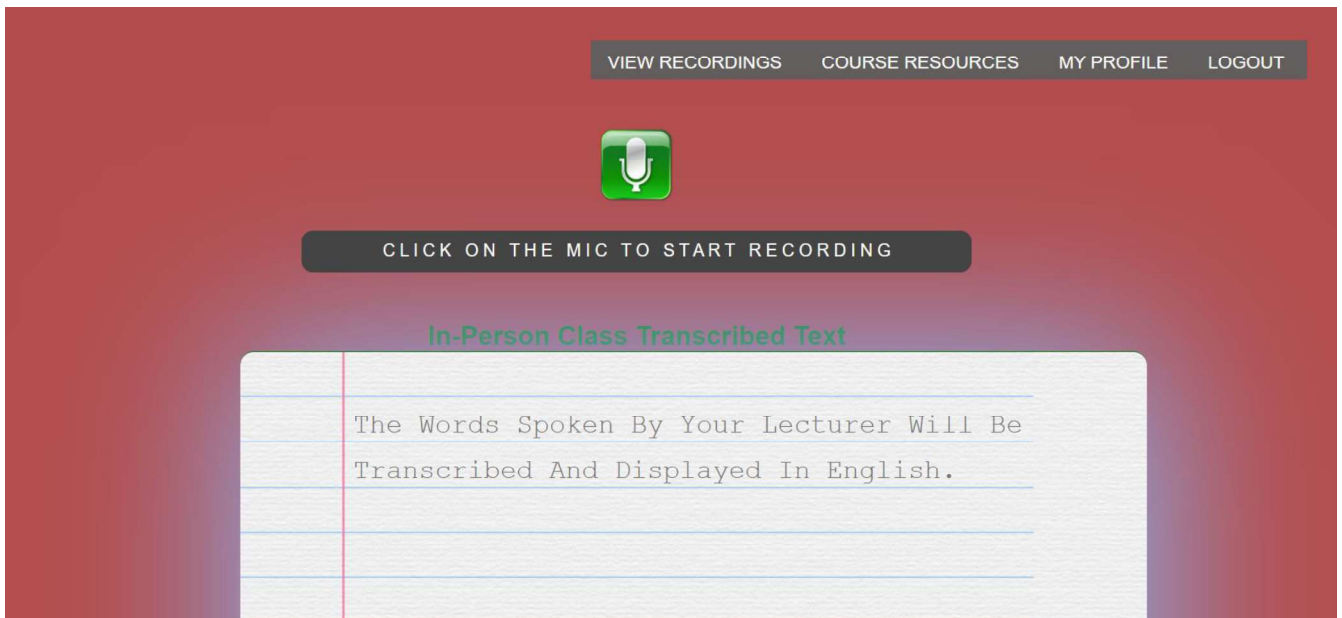
Fig 4.9

Fig 4.9: A live in-person class with the transcriber

How the transcription works

The Web version of the speech-to-text transcription works with the Web Speech API compatible with chrome web browsers. The browser provides speech input and speech-to-text-output features which web developers can utilize when building web applications.

The transcription is built using JavaScript, which interfaces with the E-learning system's HTML and CSS front-end layout. Once the user clicks on the microphone icon on the screen, it detects the microphone of the user's device and starts to record the audio in the user surrounding. It takes the continuous audio from the microphone and displays the equivalent of the text onto the web screen. The user can end the transcription session by clicking on the Microphone icon again to stop the transcription process.

Scenario 2:

In the second scenario, a YouTube video or lecture recording is made available, and the Transcriber translates the audio from the video into text. The student clicks on the button *to view recordings (Fig 4.10),* and another page is displayed, which contains a list of YouTube videos that will be transcribed into text and can be downloaded by the student.

ENROLL HISTORY

| VIEW RECORDINGS | VIEW COURSE DOCUMENTS | ATTEND A CLASS |

Enroll History

#	Course Name	Session	Department	Level	Semester	Enrollment Date	Action
1	Written & Oral Communication	Morning	Engineering Department	Freshman	Spring Semester	2022-03-22 22:24:19	🖨 Print
2	Introduction to Finance	Morning	Computer Science & Information Systems (CSIS)	Freshman	Fall Semester	2022-03-22 15:00:06	🖨 Print

Fig 4.10– User clicks on view recordings to be directed to the video transcription page

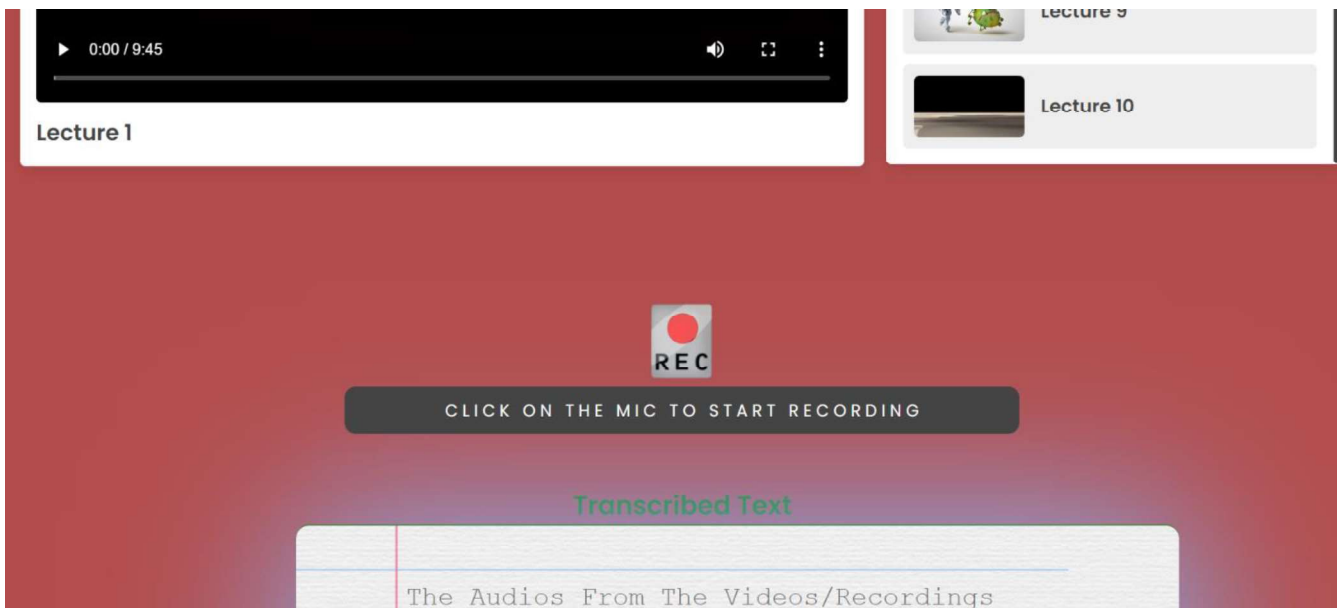The image below shows the front-end layout for the transcription function for videos or recordings.

Fig 4.11: Transcriber for recordings/videos

4.6.2 Other System Functionalities for the Student

Apart from the speech-to-text functionality implemented for the student, the system also has other features which model a learning system infrastructure. For example, the student can enroll for a particular class, view course resources, and view the classes they have enrolled in.

4.6.3 System Functionalities for the Lecturer

On the Lecturer end, the Lecturer can perform several activities such as creating a department, a semester, a session, uploading resources for the D/HH, tracking, and monitoring the activities of the D/HH student. For example, on the system, they can see the list of enrolled students in a course, monitor the login/logout time of the student. The features developed for the Lecturer was based on feedback given from interaction with Teachers of D/HH students and school Administrators One common insights that was shared is that D/HH students even in tertiary institution require support from their lecturers. Thus, in the situation when a D/HH student is using a web system, the lecturer should be able to monitor their activities and support them when needed. The image below shows the different menu tabs for the lecturer to utilize.
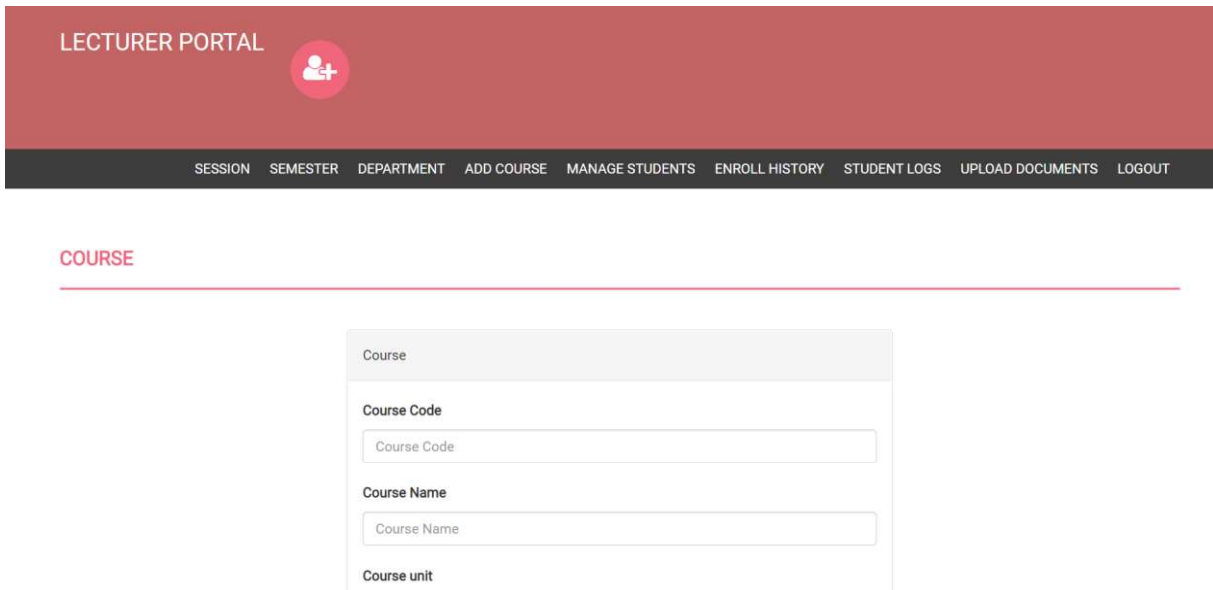

Fig 4.12: Lecturer portal

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Chapter 5: Results

This chapter discusses the results obtained from testing the E-learning system and its functionalities with the D/HH students and teachers. This chapter only contains results and insights obtained after the testing activity.

5.1 Testing

The testing activity of the E-learning system was carried at one of the disability high schools in Ghana, which is the School of the Blind & Deaf Mampong. The school for testing was selected because it had a larger population of D/HH students in the upper classes of their high school journey which is also pre-university levels. During testing, the time given to interact with the students was limited because the students had classes in session. However, ten (10) D/HH students were selected at random to interact with the student part of the learning system and one (1) teacher was also selected to interact with Lecturer section of the system. Each student interacted with the different functionalities of the system for 10 minutes and after which provided their feedback. The primary language used for communication in the School of the Deaf and Blind is sign language. Thus, through the help of a sign language interpreter, the system was described to the selected students, and they were encouraged to explore the features of the system and provide feedback on their experience.

The D/HH students had a positive experience with the system's features and suggested that the audio from the recorded videos on the system should not be too fast so that they can follow while the transcription is ongoing.

5.2 Discussion of Results

The translation functionality of the system was tested and measured over three criteria which are: Accuracy, Performance, and Usability. Additionally, other features of the system for both the lecturer and the student were tested and evaluated using Human Computer Interaction (HCI) system design principles such as Efficiency, Consistency, and Error free.

5.2.1 Results from Transcription Functionality

During a demo session, the Web Speech API and Google Cloud speech API transcription functionality was tested using several 100-words scripts read out for transcription. The *accuracy* of the transcribed text differed between the two speech-to-text API's. The accuracy was measured by comparing the text from the original script with the words captured by each of the API's. After each transcription, the following were recorded: the number of correct words, the number of incorrect words captured, and the time spent in a transcription. In each of the 100-words scripts used, both APIs performed well in transcription accuracy. However, the Google Cloud speech API had the highest rate of accurate words because it supported wider range of languages such as EN-GH (the Ghanaian English) and vocabularies than the Web Speech API.

Transcription accuracy = number of correct words/total word count

Next, the *performance* of both APIs was extremely high and effective during translation in real time. However, both transcription services depend on strong internet connectivity and there are lags in transcription when there is unstable network.

Furthermore, the *usability* and integration of the API's differed. It was easier to integrate the Web Speech API into the developed E-learning system than the Google Cloud API because the Web Speech API supports later versions of Chrome browser and a few other browsers.

However, the Google Cloud Speech API transcription service had to be converted to a REST API before exposing it to a web page where it displayed the transcribed text.

 A summary of the criteria used to measure the transcription service is given in the table below:

Table 5.1: Comparison between Web Speech and Google Cloud Speech API

CRITERIA	WEB SPEECH API	GOOGLE CLOUD SPEECH API
ACCURACY	65%	75%
PERFORMANCE	Highly	Highly
INTEGRATION	Easy	Fairly easy

Chapter 6: Conclusion and Future Work

6.1 Summary

This research explored what suitable technology will support an inclusive classroom experience for a D/HH student in a Ghanaian tertiary university. Through rigorous research and interaction with several stakeholders in the disability sector such as D/HH students, teachers, school Administrators and many more, specific system features were highlighted. This led to the development of an E-learning system which was built as a proof of concept on whether a speech-to-text transcription service can help a D/HH student understand what the lecturer is teaching and improve their English comprehension and writing abilities. The two APIs used to demonstrate the transcription functionality were the Web Speech API, and the Google Cloud Speech API. Each of these API's had its own strengths and limitations but the general similarity between them is their ability to transcribe words over good internet and with loud audio from the speaker. Additionally, the E-system developed supports both students and lecturers where the student can enroll for a class, view courses resources and the lecturer can track the activities of the student and provide the needed support.

6.2 Limitations

Despite the efficiency of the system, a few limitations were identified which can affect how the system functions. These include:

- The transcriber cannot work in a noisy environment because it cannot pick up the main sound of the speaker.
- It requires that the speaker or lecturer projects his/her voice clearly and audibly

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so that the transcriber can pick up the sound.

- It may not function effectively when the speaker's voice is transmitted at a higher frequency and speaks too fast.

- The speech-to-text API is unable to capture words that are peculiar to the Ghanaian context.

- During transcription, there were instances where the speech to text APIs displayed wrong words and the transcripts generated by the API should be looked at by either the lecturer or teaching assistant assigned to the student.

6.3 Suggestions for Future work

In building upon the work already carried out in this research, a few suggestions are stated below based on the insights gotten from the research process. These are:

- A machine learning model should be trained using data sets with audio recordings from Ghanaians. This is to help in producing better results for the speech-to-text transcription because the model will be better suited to Ghanaian lecturer's accent and can capture words and transcribe it effectively.

- The E-learning system should be more robust to include other features like chat so that the D/HH can interact with teacher, ask questions, and give his/her suggestions via a chat window.

- The system should be robust to support other learners in the classroom because in a typical university classroom, other hearing students speak in class, and this may be a challenge for the D/HH students if he/she cannot hear the questions from the hearing person in the class.

- Based on research and interaction with D/HH students, many of them in Ghana depend on sign language and would also need the services of a sign language interpreter to complement the speech to text services.

6.4 Recommendations

Inclusive education in tertiary institutions in Ghana and across Africa is important and requires more attention. In providing more solutions for Deaf/Hard of Hearing students, these are a few recommendations.

- Beyond technological system, tertiary institutions should put in place several support systems that D/HH persons can utilize in enhancing their college experience emotionally, psychologically, mentally, and even be encouraged to participate in extracurricular activities.

- A safe environment is needed for D/HH persons with maximum support possible. Based on the research findings, D/HH students face social stigma and struggle to feel safe when amongst other non-disabled persons. Thus, lecturers, teaching assistants, non-disabled students, staffs, visitors and third-party personnel should be trained on how to interact and accommodate D/HH persons.

- Industries and companies should be brought on board to expand their services to become more inclusive so that D/HH students can gain real world experiences through internships and job placement.

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Appendices

Appendix A- Online Questionnaire

Section 2: PERSONS WITH DISABILITY STUDENTS/PARENTS/GUARDIANS

If you are a Parent/Guardian, you are required to provide details on behalf of the student.

Gender *

○ Male

○ Female

○ Other

How old are you?

○ 8 - 15 years

○ 16 - 25 years

○ 26-45 years

○ 45+

What is your level of education? i.e (JHS 1-3, SHS 1-3, University)

○ JHS 1- 3

○ SHS 1- 3

○ University

Do you identify yourself as a person with disability? Why? *

Your answer

If yes, what disability do you have? *

○ Visually impaired

○ Hearing impaired

○ Dyslexia

○ Attention Deficit Hyperactivity Disorder (ADHD)

What is the origin of your indicated disability? *

○ From birth

○ illness/diseases/health issues

○ Accident

○ Other

If you indicated 'other' in the previous question, please specify the disability origin below:

Your answer

If you are a parent or guardian, are you homeschooling your child or ward?

○ Yes

○ No

If you are a parent or guardian, provisions/infrastructures in place to support disabled students in your homes? E.g.(sign language applications, braille screen readers, text-to- speech applications etc.)

Your answer

Would you want to use technological applications in your educational journey? Why? Mention some features you would like to see in the application.

Your answer

Any other comments?

Your answer

Section 3: SCHOOL/UNIVERSITY ADMINISTRATORS

Please provide details about people with disability in your school or university and the institutions provisions and policy for inclusion.

Name of institution

Your answer

What is the total population of students in your institution ? (please specify in numbers)

Your answer

What is the total population of disabled students in your institution? (please specify in numbers)

What is the total population of disabled students in your institution? (please specify in numbers)

Your answer

What are the provisions/infrastructures/policies in place to support disabled students in your institution? E.g.(sign language applications, braille screen readers, text-to- speech applications, railings/ramps, etc.)
*

Your answer

Any other comments?

Your answer

Back   Submit   Clear form

GHANAIAN IT INDUSTRY

Name of Company *

Your answer

What technologies/tool have you used/developed to support inclusion of persons with disabilities(that Ghanaian universities can leverage on to teach disabled students)

Your answer

Will you be willing to partner with Ashesi University to develop inclusive technologies for university education? (Such partnership can be through co-supervising capstone project, mentoring inclusive entrepreneurship ventures, internships)

○ Yes

○ No

If you answered yes or maybe to the question above, please provide your email address for contact

Your answer

Any comments?

Your answer

Back   Submit   Clear form

Section 2: PERSONS WITH DISABILITY STUDENTS/PARENTS/GUARDIANS

If you are a Parent/Guardian, you are required to provide details on behalf of the student.

Gender *

○ Male

○ Female

○ Other

How old are you?

○ 8 - 15 years

○ 16 - 25 years

○ 26-45 years

○ 45+

INTERVIEW QUESTIONS FOR PERSONS WITH DISABILITIES

These interview questions were created to collect qualitative data through one-on-one in-person or virtual meetings and focus group discussions.

INTERVIEW QUESTIONS FOR PERSONS WITH DISABILITIES

DISABILITY RESEARCH INTERVIEW QUESTIONS ASHESI CAPSTONE 2021 PROJECT THEME: DEVELOPING AN INCLUSIVE AND INTELLIGENT LEARNING SYSTEM FOR PERSONS WITH DISABILITIES. DISCLAIMER: ALL RESPONSES TO THE QUESTIONS ARE ANONYMOUS AND CONFIDENTIAL AND WILL BE ONLY USED FOR RESEARCH PURPOSES. EACH RESPONDENT HAS THE CHOICE NOT TO ANSWER QUESTIONS THAT SEEMS TO BE CONFIDENTIAL OR PERSONAL TO THEM.

SECTION A

GENERAL QUESTIONS Note: These questions are meant to give a better understanding of the respondent's disability type

1. Would you want to be identified/classified as a person with [cognitive (ADHD, Dyslexia), mobility/motor, Vision loss, Hearing loss]? 2. Can you tell me about your [DISABILITY NAME]? (i.e., Vision loss, ADHD, Hearing loss, Dyslexia)

The focal point (for the interviewer): Extent – mild (blindness, color blindness, low vision, visually impaired) to extreme

3. For how long have you had this disability (i.e., from childbirth or at some point in your life – accident, illness)? (Feel free to respond or not)

COMMUNICATION QUESTIONS

Note: These questions are asked to understand the communication level of each respondent better

1. Tell me about how you communicate with others.

2. What are some of the challenges you face communicating with others?

3. Do you require any assistance when communicating with others? If yes, what kind of assistance do you need? Does it depend on the use of technology?

4. Tell me about a time you were misunderstood. How did you navigate that? 5. Have you had regretful experiences and encounters with people's attitudes? Tell me about it?

EDUCATION

Note: These questions are asked better to understand the education level and activities of the interviewees.

1. Tell me about your educational experience? What were the achievements or challenges you faced in your journey?

2. Can you share some of the challenges you have faced in your learning journey in class and outside the Classroom?

3. What level of education are you in?

4. How have you coped in your educational journey?

5. What are some of the challenges you have faced in your learning journey in and outside the Classroom?

6. Are there any aids or modifications that make it easier for you to get an education, such as

portable spell checkers, extra Time for exams, or accessible classrooms? *–Tell me about such aids?*

7. How comfortable are you with speaking in a classroom discussion?

TECHNOLOGY

Note: These questions are asked to understand better-existing technologies the interviewees have used and what technologies they would like to use(if they have never used any).

8. Have you used any assistive technology in the past? What did you like about it? Was it useful? What do you wish could be better about it?

9. What other assistive devices (DISABILITY TYPE) would you need to help you learn?

10. Does your current educational institution make it easy for you to learn?

A. If yes,

i. What structures are there to support you?

B. If No,

i. What are some of the provisions (e.g., devices, technologies) you hope to see in an educational institution to support you in learning?

N.B. (for the interviewer): Avoid leading questions.

11. Have you used any technological device to support you in learning any material in the past?

A. If yes,

i. Can you describe your experience with it?

ii. Was it beneficial to you?

ii. Is there any design flaws with the technology?

iii. If yes, how can the technology better suit your need?

12. Do you use any assistive devices to help you get around or to accomplish other tasks?

If yes,

i. What tasks?

ii. What are the devices that you use and their functions?

DEAF AND HARD OF HEARING PERSONS

Do you use any assistive devices to communicate better?

A. If yes,

i). Which ones do you use?

B. If No,

i). Which assistive devices for hearing and communicating do you need?

2. Do you think you need other things to help you see and read better?

3. Do you have any dreams or aspirations?

If yes,

i). What are they, and what would you need(technological and emotionally wise) to accomplish

them?

Do you know how to communicate with sign language?

A.If yes,

i). What is your level of proficiency?

If No,

i). Would you want to learn sign language?

If you have to use a sign language application

    i.   How would you want to be supported with a sign language application?

    ii. What features do you expect to see in the application?

    iii. How useful will it be to you?

What kind of software solution would aid you in your learning? (Web-based, Mobile e.t.c)

ADMINISTRATORS

1. What provisions (infrastructures: ramps, automated doors, technologies: translators, transcribers, devices: braille) do your institution provide for people with disability?

2. Based on your experiences, which of these provisions (from question 1) has/have been effective?

3. What percentage of persons(students) with disabilities do you have at your institution?

4. What is the percentage distribution of disabilities at your institution (visually impaired, deaf or hard of hearing, autistic student)? 5.[FOR TEACHERS] In your experience teaching persons with disability, what teaching strategies have you identified to work for all or any of the categories of disability

Appendix B

DISABILITY RESEARCH CONSENT FORM

On behalf of the intelligent learning system team, I would like to ask you for your permission to be part of this interview with persons with disabilities. This study aims to understand the educational challenges faced by persons with disabilities. Your participation in this interview will immensely contribute to identifying challenges in the educational journey of persons with disabilities. Also, the insights you will share will guide the team in identifying the needs of persons with disabilities that can be solved using technology.

You are free to respond to questions and opt out of this activity once you notice that the questions being asked compromise your confidentiality. The risk of being part of this study is potentially emotional stress and Time lost. The benefit of being a part of this study is that you will be contributing to enhancing solutions that would be developed to increase the educational opportunities for persons with disabilities in Ghana.

If you have any questions, feedback, or suggestions, please email

one of the members of the research team - hephzibahemereole@ashesi.edu.gh or the supervisor

dadjepon@ashesi.edu.gh

If you agree to be part of this interview process, please sign below with your name.

Participant name ———————————— Date: ————

Thank you very much.

Disability Research Team

Ashesi University

Appendix C

ASHESI IRB REQUEST FORM

Request for Human Subjects Approval

Application Form for Final Year Capstone Project
(This form should not be used for health and medical research project)

Use this form for <u>initial</u> approvals and protocol modifications. To renew an approval after one year, please use the Continuation Form.

Submit this completed form and your proposal with all required elements as email attachments to the office of the Provost, Ashesi University College: (irb@ashesi.edu.gh)mailto:human.subjects@emich.edu.

☐ Applied ☒ Thesis ☐ Entrepreneurship

☒Semester 1☐Semester 2

Date Submitted:	*November 17, 2021*
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Is this application	*New*