

# E-Learning Platform for Hearing Impaired Children with Handwritten Character Recognition using CNN

MMK Rowel<sup>1</sup>, ADAI Gunasekara<sup>2</sup>, GAI Uwanthika<sup>3</sup> and DB Wijesinghe<sup>4</sup>

<sup>1,2,3</sup>Faculty of Computing, General Sir John Kotelawala Defence University, Ratmalana, Sri Lanka

<sup>4</sup>Faculty of Computing, General Sir John Kotelawala Defence University, Sooriyawewa, Sri Lanka

<sup>1</sup>35-se-0022@kdu.ac.lk

**ABSTRACT** Hearing impairment is an example of a disability that can affect a child's education in a variety of ways. E-learning has been proved to be an excellent learning approach for students as it provides many advantages. One advantage is that children can save their time as it provides the opportunity to engage in studies from anywhere in the world. Although the e-learning method may have various advantages, it also has several disadvantages that need to be addressed. This online learning technique may not be as helpful for children under the age of five as it is for the older generation. For children with hearing impairment, this strategy of education will be even worse. Hence, these children should have an appropriate alternative for learning letters and numbers during crisis situations. The major goal of this study is to critically evaluate the need for an alternative solution. The suggested e-learning platform helps children learn letters and numbers step by step. This platform also teaches children to write numbers and both Sinhala and English characters. In order to recognize the letters and numbers children write, the system uses convolutional neural networks (CNN). In addition, the system provides basic quizzes and activities to ensure an engaging/interesting learning process. This study was conducted with the goal of improving the effectiveness of e-learning for hearing impaired children.

**KEYWORDS:** CNN, Crisis Situations, E-Learning, Handwritten Character Recognition, Hearing Impaired Children

## I INTRODUCTION

Every person on earth should have access to education and every child should have access to education and school regardless of where they live. Children with hearing loss should also have access to such facilities but those children go through various difficulties when engaging in the process of education. Sociocultural attitudes and crisis conditions such as public health, and environmental catastrophes are all major impediments to learning for hearing impaired children.

Distance education, often referred to as e-learning, was introduced as a new approach as a result of the advancement in technology in the field of education. E-learning is an important component as the younger generation relies on technology to go through challenging times. In e-learning, students and teachers are physically separated. However, at the same time, students and teachers have the ability to communicate with each other online and offline. One of the most common methods of distance

education is video conferencing. Video conferencing is the most common way for students to interact directly with their teachers during live lessons [1]. Students with disabilities can benefit greatly from this technology as they can complete their education at home without having to leave home. Due to their socio-cultural realities, some students with disabilities are reluctant to attend standard classes to complete their studies. As a result, distance learning or e-learning may be beneficial for students like them [2].

World health organization stated that almost half a billion people worldwide have hearing impairments and more than 30 million of them are children [3]. One of the most significant and contentious problems in deaf history is deaf children's capacity to obtain and access education [4]. For many years, deaf or hard-of-hearing children were counseled primarily through sign language. Deaf individuals communicate with others via sign language. It is thought to be one of the most recent research topics in the history of science.

E-learning is known as a modern method that can be used for education. It does not require physical presence of students in a classroom. It can be considered as a great opportunity to engage in education remotely anywhere in the world. E-learning is known as a method of education that is based on student-student interaction (SSI), student-content interaction (SCI) and finally the most common relationship, student-instructor interaction (SII) [5]. However, this method requires several electronic devices such as laptops or smartphones or tablets and Wi-Fi. Those who are unable to afford to find such devices will have to face some difficulties in engaging in their education [6]. Many people nowadays benefit from e-learning, including differently abled people. This method can only adversely affect anyone's life if they are not familiar with the newest technologies [7]. Hence, it is important to keep people informed about the latest technologies and upcoming trends.

Differently abled children require more attention than other children. A typical online classroom for them would not be as effective as it would be for other children, specifically when it comes to learning letters and numbers. A structured environment is highly required for hearing impaired children to succeed in their education. Some of the researchers who are in the field of e-learning have found several methods and techniques that can be used to overcome the above mentioned barriers. The issues they have faced when developing those systems and the advantages of the techniques and the methods they used will be discussed in this study. The major goal of this research is to provide a mechanism for hearing-impaired youngsters to complete their education even in the face of a crisis. This study will present a way for learning numbers and letters in both English and Sinhala.

The significance of this research is that this study is based on e-learning platforms for hearing impaired children. The idea of e-learning platforms for children with disabilities is an emerging trend in the field of e-learning. Therefore, this study pays a careful consideration on the existing e-learning platforms for hearing impaired children and the technologies and trends used by other researchers to solve existing problems. Also, this study presents a developed model that can be used to solve the existing problems.

## II LITERATURE REVIEW

Researchers have observed various techniques and methods that can be helpful for hearing impaired children in their education. Researchers working in the field of e-learning have seen the usefulness of e-learning for them from several angles. This section of the study attempts to identify the proposed perspectives of researchers which can later be

used to analyze the technologies and the newest trends they have used. According to Saunders, Lewis and Thornhill, the literature will support the research question and objectives providing a complete justification for the research aim and objectives, gaining insights as per the outline of the research and providing important information and ideas for other researchers [8]. Therefore, this section is structured in accordance with the research objectives.

### A Existing Systems

There are many e-learning platforms currently available for hearing impaired children and the content of most platforms is based on Math, general education and communication. Some of the studies that were done by researchers are as follows,

Table 1 : Existing studies on e-learning for Hearing Impaired Children

Name of the Study	Participants	Areas Based On
“A Gamified E-learning Framework for teaching Mathematics”	Deaf students	Mathematics
“Adaptive Learning System and an Academic Advisor Agent”	Deaf students	General Education
“Design an Application for the Hearing Impaired People”	Hearing Impaired People	Communicate with others
“Deaf Students Higher Education using E-Learning”	Deaf Students	Higher Education
“E-learning course based on AdAPI”	Deaf and hard of hearing participants	Computer literacy

Table 1 covers a wide range of subjects taught to hearing impaired children and adults. The system implemented by Samaa M. Shoheib is a gamified e-learning framework that can be used to teach mathematics to hearing impaired students. According to the author, Gamified is an approach to accelerate the experience curve of teaching, learning and thinking in education. Simply, gamification is an application of game planning elements and game principles in non-game contexts. The general contents of the implemented system were, content, Arabic sign language avatar, quality standards, learner support as well as characteristics, and gamification components. The content of this study contains the course syllabus, structure, quantity, depth and activities. The learner support includes grading, feedback and guidance. Grading and feedback are given using score and instant feedback. These are included in the

gamification components. Special guidance is provided using the Arabic sign language avatar. Gamification components that were used in this study were, points and performance graphs, challenges, badges and achievements, leader modes, levels, time based activities, stories and characters as well as freedom to fail [9].

The main objective of the adaptive learning system proposed by [10] was to monitor the student's achievement in the learning program and instruct them to do better. They proposed this system to overcome the difficulties hearing impaired learners face. According to the researchers, some of the challenges hearing impaired people face are, difficulties in writing and reading online and being compared with other normal students, grammatical errors they make when writing, and not having tutors who are willing to educate them without any hesitations as most of the tutors find it difficult to teach hearing impaired students. For the above mentioned problems, authors proposed a solution based on a set of defined skills that would help hearing impaired children to enhance their knowledge in writing and reading. These skills were specified as DSLO's ("Deaf Students Learning Outcomes") [10].

Matjaz ˇ Debevc and others have created an e-learning environment that is adapted for people with hearing disabilities. In this study, the utility and educational effectiveness of the e-learning curriculum were evaluated using an inventory and adapted education index system that measures software usage. The researchers have used sign language videos to teach hearing impaired students to make the system more effective for them [11].

Researchers were able to design an application for smooth communication and for an easy life of the hearing impaired people. For this, sign language, voice to text translation features were included. In addition, a vibration alarm was added for the safety of the people[12].

### B Approached Techniques

This section contains the technologies and the approaches used by the above mentioned authors to implement the systems they proposed.

According to Samaa M. Shoheib, Gamified is an approach to accelerate the experience curve of teaching, learning and thinking in education. Simply, gamification is an application of game planning elements and game principles in non-game contexts [9]. This is known as a game based method. Hence the goals of the system are presented to users as games. A study was undertaken, to assess the usefulness of this strategy by using a gamification plugin in a learning management system. The results show that the gamification method has better effects than the traditional

Table 2 : Technologies used in Proposed Systems

Name of the Study	Approached Techniques
"A Gamified E-learning Framework for teaching Mathematics"	Gamification, Arabic Sign Language (ArSL), Animation
"Adaptive Learning System and an Academic Advisor Agent"	N-tiers, Multi-Layer architecture, Multi agent system, Model View Controller pattern maintenance
"Design an Application for the Hearing Impaired People"	Sign Language, Voice to text translation
"Deaf Students Higher Education using E-Learning"	Cloud Computing, Big Data, Video Streaming, Text
"E-learning course based on AdAPI"	Video Streaming (sign language and subtitles), Animations

education system.

### C Effectiveness of E-learning for Hearing Impaired Children during Crisis Situations

With the development of the world, distance education also known as e-learning has started growing rapidly all around the world. It has also become the major solution to provide education to the younger generation in difficult times. The effectiveness of e-learning cannot be analyzed just by comparing it with the traditional education system as both the systems have many advantages as well as disadvantages, especially in times of crisis.

According to the authors, the distance education system is the most effective and efficient way to continue education in crisis situations. During crisis situations people are stuck at home unable to go anywhere. There are times when people are not able to get the essential products for themselves. In such situations, advanced technology is needed in order to manage the situation. As a result, distance education was developed to address all the barriers that affect the education sector in a country.

According to Oliveira, in a crisis situation, schools and institutions are closed to prevent external damages. Hence there won't be a place for students to do their studies. In the distance education system, a specific place is not required for students to engage in their studies [13]. Students are able to engage in their education at home. In the traditional education system, the teacher may have to teach the same subject to different classes at different times but with the distance education system the teacher or the tutor has the ability to conduct only one session (video) and can ask students to join that at the same time. It is much easier than teaching the same lesson at different times.

According to the researchers, distance education requires 40-60% less time to learn than in the traditional learning system [14]. The main reason for that is that students have enough time to self-study and clarify the queries on their own. According to the authors, the effectiveness of distance education varies among age groups. Since young children require more attention they require physical activities as well as in depth guidelines.

### III METHODOLOGY

The architecture of the system was broken down into four main components and they are, software architecture, database, modular architectures as well the interfaces of the system.

#### A Data Gathering

To gather the required data for the development of the system were done using data collection protocols such as interviews, questionnaires and documentary reviews. The main purpose of this system is to deliver an effective learning method for hearing impaired children that can be used to ensure that they gain education even in their difficult times.

#### B Data Analysis

Data required for the implementation of the system were analyzed using charts and diagrams. In the analysis process, problems and difficulties faced by hearing impaired children were identified. This helped the authors to discover the need for a new learning method for hearing impaired children in times of crisis.

#### C Approach

Main users of this system are hearing impaired children and lecturers or teachers of hearing impaired children. There are two types of inputs for the system. They are basic information such as the name, date of birth etc. of hearing impaired children and uploaded course materials by teachers.

#### D Technology Adapted

To gather user inputs through sign in and registration modules, the system has been implemented using HTML, CSS, JavaScript and firebase. These technologies were used by considering the functional and non-functional requirements of the system. It is important to develop a system that satisfies the requirements of the users. Proposed e-learning platform for hearing impaired children is a web based system. Non-functional requirements such as availability, security, learnability and usability were mainly considered when developing the system. To develop the frontend of the system,

Html, CSS, JavaScript were used with visual studio code. To develop the backend of the system, CNN, python, Jupyter notebook and firebase were used. Since the main goal of this system is to teach hearing impaired children how to write letters and numbers, CNN was used to recognize the handwritten text and digits.

#### E Proposed Design

The architecture of the system was broken down into four main components and they are, software architecture, database, modular architectures as well the interfaces of the system.

##### 1 Overall System Architecture

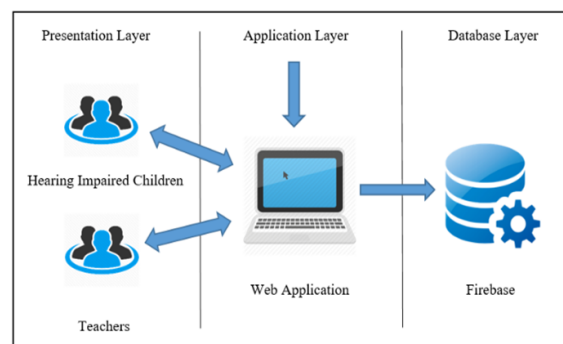


Figure 1 : Overall System Architecture  
Source: Author

**Presentation Layer** - This shows information about the system and the web application. It is a user friendly layer and is the front part of the system. In this layer, user interfaces of the system are largely considered. User interfaces of this system are eye catching and graphical.

**Application Layer** - The application layer consists of the web application. The application layer presents the functional logic that shows the basic functionalities of a web based system. It is an abstracted layer that connects to the other two layers as it acts like the central part of the entire system. This layer presents a detailed configuration of the system.

**Database Layer** - The database layer consists of databases, tables, records, etc. It has database servers that can be used to store all the required information. This layer is independent of the application layer and the presentation layer. This storage will be used to ensure the efficiency of all operations related to the database of the e-learning platform.

##### 2 Modular Architecture

Overall modular architecture of the e-learning platform is shown using figures. The modules of the system are



mentioned below with related interfaces.

**User Profile** - Every user will have their own user profile. The details which were entered by the user will be displayed in their user profiles. Details such as, name, age, and courses they follow on the platform.

**Course Selection** - There will be several course materials for hearing impaired students to access. They can choose to follow any of the included courses in the system.

**Letters and Numbers Identification** - This module includes an algorithm to identify the handwritten texts and digits entered by the users. The recognition of handwritten characters and letters is done using convolutional neural networks.

**Feedback** - Users can send their feedback on the course material they follow or regarding the system. They will be given a section to add their comments on the platform. For this a feedback form will be provided.

The developed e-learning platform for hearing impaired children is based on colorful themes and colors because children require eye catching interfaces. Figure 2 displays the home page of the platform and figure 3 displays the course selection interface of the system. Figure 6 is the sign up interface for children.

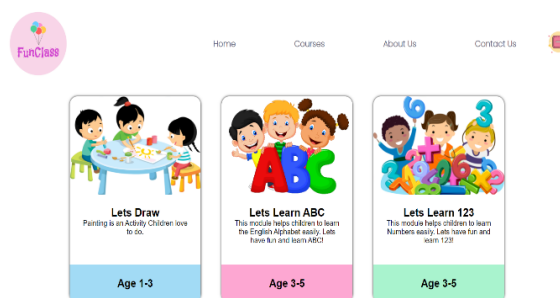


Figure 3 : Course Selection Interface  
Source: Author



Figure 4 : Sign Up Interface  
Source: Author



Figure 2 : Home Page of the System  
Source: Author

## IV RESULTS AND DISCUSSION

Hearing impaired children are in need of an effective solution to continue their education in times of crisis. A typical online classroom where teachers talk and students listen would not be effective for them at all. Therefore, an e-learning platform was proposed to be used as an alternative which hearing impaired children can use to learn letters and numbers with proper guidelines. This allows children to draw letters and numbers on their own.

To recognize the numbers and letters written by children, CNN is used. For this, a dataset consisting of 100 images

per digit was used. This data set was split into two sets. 20% were used for the training process of the dataset and 80% were used for testing. For English and Sinhala character recognition the same approach was used. 100 images were used for each letter. The entire data set was then split into two sets for training and testing process.

## V CONCLUSION AND FUTURE WORK

The main purpose of this research is to provide HIC with a better way to complete their education in times of crisis such as public health, political and environmental disasters. In times of crisis, learning letters and numbers has proven to be a daunting task for young people. Some of the existing e-learning systems are inefficient and inefficient compared to traditional school education. We were able to overcome these challenges by creating an e-learning platform that teaches hearing challenged youngsters how to learn and write letters and numbers in a step-by-step manner.

This article recommends a web-based e-learning platform with a variety of course resources for teaching students how to write letters and numbers. This system will be expanded to accommodate more course content for other age groups and for other differently abled youngsters. Furthermore, this way of learning will be offered to a group of youngsters who are suffering from hearing impairments and their feedback will be taken. The system will be

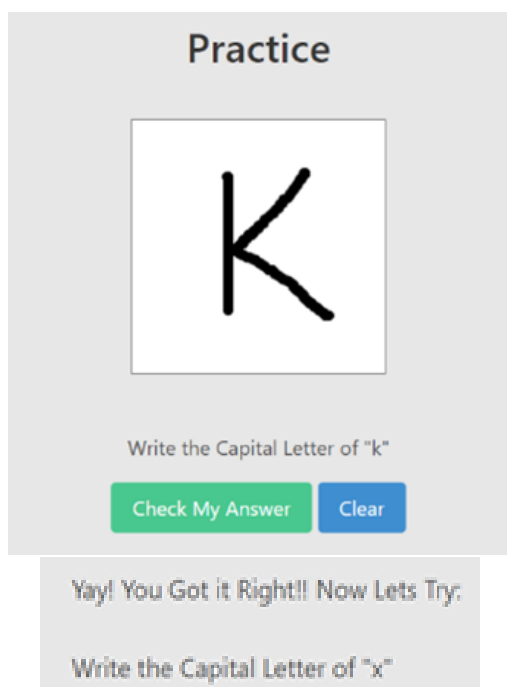


Figure 5 : Prediction of Characters  
Source: Author

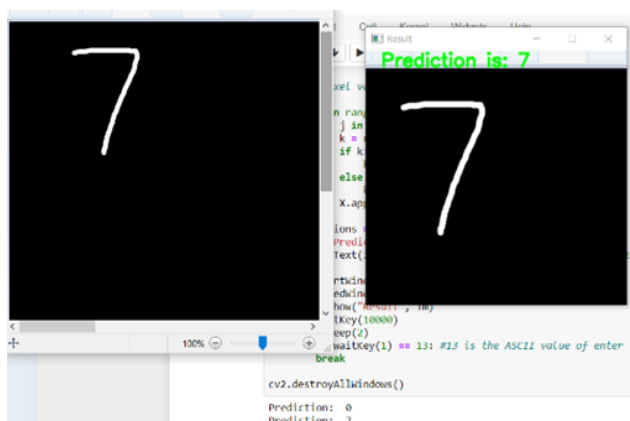


Figure 6 : Prediction of Handwritten Digits  
Source: Author

improved based on the comments received to make it more beneficial for children.

This platform can be very useful for children who struggle with learning letters and numbers in times of crisis. Some parents find it difficult to persuade their kids to sit in one place and study, especially when they're at home. Children seek entertaining activities. Hence, this platform will help not only children but also parents in educating their children.

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Dr. Asela Gunasekara has graduated from London Metropolitan University, UK with 1st Class Honors. He has acquired his Postgraduate Diploma and Masters degrees from University of Colombo. He was awarded a full scholarship by the People's Republic of China to follow his Doctoral studies. He was awarded as the Outstanding International Student, Academic Excellence Award and as the Honorary International Student for his outstanding performance during his Doctoral studies at Huazhong University of Science & Technology, China. His doctoral thesis is on Usability Heuristics in Human Computer Interaction. He is an active researcher in Human Computer Interaction and E-learning. He has 14 years of academic experience and at present he is the Dean of Faculty of Computing in General Sir John Kotelawala Defence University.



GAI Uwanthika Received BSc(sp) in Computer Science and Technology degree from Uva Wellassa University. Currently pursuing her master's degree at University of Peradeniya. The main research interests include Bioinformatics, Deep Learning and Digital Image

Processing.



Diunuge B. Wijesinghe is a lecturer at Faculty of Computing, General Sir Kotelawala Defence University. Diunuge B. Wijesinghe obtained B.Sc. Eng. (Hons.) in computer science and engineering from Faculty of Engineering, University of Moratuwa, Sri Lanka in 2015. He worked as a CEO at Nandimith Labs, Visiting Lecturer in Edith Cowan University, UCHS at Jayawardanapura Hospital, IESL College of Engineering and University of Moratuwa, Sri Lanka. His current research interests are data science, cyber security, accelerated computing, intelligent systems, and automation. Eng. Wijesinghe holds the associate membership of IESL (Institute of Engineers Sri Lanka).

## ABBREVIATIONS AND SPECIFIC SYMBOLS

- CNN – Convolutional Neural Network
- HIC – Hearing Impaired Children

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## AUTHOR BIOGRAPHIES



MMK Rowel is currently a BSc. Undergraduate at the faculty of computing, General Sir John Kotelawala Defence University. Current research is about Machine Learning based E-learning Platform for hearing impaired children that can be used to learn numbers and letters of

both Sinhala and English languages.