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Interactive and Adaptive Learning Tool for Special Need Kids

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Abstract:-
The research presented here outlines the development of an engaging educational mobile application for kids with exceptional disabilities, aimed mostly at 5 to 8-year-old blind, deaf, and mute children. There are four main components to the application: audio lectures and tests for kids with visual impairments, improved penmanship and mathematics quizzes for the deaf, interactive Braille tutoring for kids with visual impairments, and instant sign language interpreter for the deaf/mute. Every element makes use of cutting-edge technology like the Google Text-to-Speech API, Optical Character Recognition (OCR), Natural Language Processing (NLP), EasyOCR, image processing, Deep Learning models, etc.

Regarding the design and the content of the application, it was designed and created together with educators working in specialised institutions and schools. As for the main contribution of the study, it is explained that our approach focuses on transfer learning with the help of models such as VGG16 to achieve high recognition rates of signs from ASL in real-time, thus, balancing between speed and efficiency. The findings reveal strength in special needs children's educational participation and academic achievements. This work, therefore, points to the imperative of applying modern technology in the offering of special education for integration.

Keywords*: Special Needs Education, Mobile Learning Applications, Visual Impairment, Deaf Education, Braille Literacy, American Sign Language (ASL), American Sign Language (ASL), Optical Character Recognition (OCR), Machine Learning in Education.*

1. Introduction

The Education of children with special needs such as blindness or deaf/mute is not easy and calls for peculiar approaches. Thus, the traditional approaches to learning can hardly satisfy the requirements of these children and take into account their individual needs because such children may have gaps in learning. The rise of modern technology gives a chance to develop individualized instruments inseparable from the school for special operations that would help improve children's learning processes.

This research project aims at Creating an Educational Mobile Application; for children within ages of 5 to 8 years and who are either blind, deaf or mute. The app aims to provide an inclusive and engaging learning environment through four main components: The app aims to provide an inclusive and engaging learning environment through four main components:

A. Audio Lessons and Quizzes for Visually Impaired Kids.

This component converts the lessons into audio format with the help of Google Text-to-Speech API. The application has aspects like choice of speed and volume of the lesson, as well as the ability to repeat a lesson. Tests are given to revisit knowledge in the form of quizzes and a voice recorder to record/assess the children's answers. Moreover, due to the integration of OCR and NLP, the app can form questions related to the English language using the scanned text.

B. Enhancing Writing Skills and Math Quizzes for Deaf Kids

This module builds on sign language GIFs to teach the words, with technology evaluating the children ' Easy OCR documents that contain the handwriting of words to be taught. The math quizzes involve addition and subtraction problems, and each problem comes with a button of animation showing the solution, this makes it easier for learners to conform through interaction.

C. Interactive Braille Learning and Quizzes for Visually Impaired Kids.

This section focuses on giving the Braille alphabet both in the auditory and the visual modality to assist the guardians to teach their children. The lessons are divided into five segments, then the writing of words in braille by children. Image processing technology is used to evaluate their answers, providing feedback on their progress.

D. Real-Time Sign Language Translator for Deaf/Mute Kids.

This component uses ASL sign recognition through a deep learning model and it uses transfer learning mechanisms like VGG16 for fast and accurate predictions. The app comes with a learning program wherein the children are introduced to ASL signs and is given tests to check their learning with the app giving feedback and tracking record.

This research is of great importance since the identified trends indicate a possibility of developing unique learning environments in the field of special needs education through the application of modern technologies. The purpose of this project is to enhance the quality of education and learning experiences of blind, deaf, and mute students as well as the special needs they have by offering those tools particularly created for their needs.

The subsequent sections of this work shall give a brief understanding of the research work and findings in relation to the literature review, methodology, results, discussion, and conclusion.

2. Objectives

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3. Methods

A. Research Design

The framework for this study employed the underpinned iterative and participatory type of research to design and assess the efficacy, effectiveness of an education application that targets children of 5 years to 8 years, with special needs. The strategy also combines the feedback-closing with the educators, parents and special education specialists during the creation process of the methodology. This cyclical process enable for petting of the application’s functions in the right direction of catering for the educational needs and wants of the visually impaired, deaf, and mute children.

In terms of technology the application employs an elaborate template containing Python for the back end development, OpenCV for gesture analysis, React Native for cross platform mobile application development and deep learning with TensorFlow and Keras and Amazon Web Services and Firebase for data management and processing. These technologies allow for the inclusion of additional components combined with such options as real time ASL recognition, learning games, and customizable quizzes according to the peculiarities of special needs children’s learning capabilities.

Ethical considerations shape the overall process of designing the research with attention to the set of norms that regulate participant anonymity, the procedure of obtaining participants' consent, as well as considering children's rights and their legal guardians. This approach not only helps with the ethical undertaking of the study but also graces the application with win-win beneficial properties concerning applicability in various school settings and cultures.

B. Participants

The analysing sample of this research is a selected group of children aged 5 to 8 of different types of challenged children, children with visual impairments, deaf children, and those with muteness. Participants include children with Special Needs who are enrolled in Special School System thus the study focuses on the right population. Besides children, parents and guardians are also necessary participants for the study, as they make reflexive comments on the educational application's use, efficacy and outcomes.

In this respect, maintaining the ethical consideration of the participant is followed from the point of participant recruitment to the engagement of the participant in the study. Particularly, there is adherence to the principles of protecting the identity of participants, participants' voluntary consent, non-exploitation of children in the research process, and their guardians. The specific objectives of this ethical decision-making framework are as follows.

C. Data Collection

The data collection phase of this research incorporates the development phase of the application as well as the evaluation phase of this educational application for special needs children. The proposed two-part usability study is to incorporate a two-wave approach of quantitative assessment of usability, functionality, and educational outcomes with the participants' feedback.

In the development phase, this process invites the circulation of feedback from stakeholders like teachers, parents, and specialists in the special education branch. This enables them to frequently enhance as well as test the attributes and capabilities of the application in question. It is given using explicit and implicit questions during usability tests, focus group discussions, and interviews to make real changes such that the materials and modes of instruction are friendly and helpful.

The valuation phase concentrates on reviewing the efficacy of the created application in generating educational outcomes. Parametric measures that include the time users spend on the application and the rate of correct recognition of ASL signs are collected to assess the level of performance. The quantitative data, collected through the polls conducted with users and interviews are more informative about the satisfaction, usefulness, and further recommendations.

Both phases observe ethical aet that participation information remains anonymous; participants' consent is sought, and participants especially children and their guardians are treated with respect. Issues to do with ethics are critical in establishing the right environment of the research through protecting rights and wellbeing of all individuals participating in the research. Smart learning for special needs children: this methodological approach is intended to provide reliable results that advance knowledge regarding the design of special needs kids' education technologies.

D. Implementation Steps

The implementation of the educational application for special needs children followed a structured and iterative process to ensure the development of a functional, user-friendly, and effective learning tool. The implementation steps included initial development, iterative testing, feedback incorporation, and final deployment.

Initially, the application was developed using the selected technologies and tools. The development process began with setting up the project environment, installing necessary libraries and frameworks, and creating the initial codebase. This phase involved configuring the Google Text-to-Speech API for audio output, integrating TensorFlow and Keras for machine learning functionalities, and setting up Firebase for data storage and user authentication.

After that, we retrial the application in order to find some bugs or issue in order to enhance th application. This phase involve testing specific function and subprograms or modules making up a large system, testing of interfaces between different modules, and overall testing of the entire program. Particular emphasis was made in terms of the efficiency and precision of the model for sign language identification using ASL, understandable audio lessons, and the convenience of the interface.

During the testing of the applications, the input of teachers, parents, and children with special needs was collected and discussed in subsequent cycles. This feedback proved very useful to make a list of changes and improvements that served to enrich and refine the characteristics and options of the application. For instance, adaptations were made amid the speech recognition system to accommodate the kid's voices, and proper changes were made to the touches interface so that the specifically impaired vision users could find the screen easy to browse.

This made the process of changing the application to better respond to feedback to take several circles. Advanced changes to the fluent its performance or correct outcomes of the machine learning models were undertaken, soundbank enhancements to reap improved audio playback quality and changes to devise UI to enhance usability. After every change increment, there was more testing to confirm that the change would not affect the usability of the application and the experience of the user.

The final deployment phase included finalization of the application ready for use to the target user group. Some of the points that have been noted include creating a secure and elastic foundation on Google Cloud platform, completing the processes of the application packaging, and performing various quality assurance tests. Reference information was also prepared to guide the end-users on how to use the developed application and how to solve some of the problems that may be encountered.

They were next launched to the users with requisite assistance in installation and initial experiences with the application. To ensure that the application is functioning well and to gauge the users' satisfaction, the monitoring system was set up for recording users' activities. This was done to coach the needs of the special needs children to be fit in the application adequately and make any alteration that may have been observed.

All in all, the implementation process was performed in a cooperative and cyclic manner focusing on creating an effective and easy to use educational application modified to the needs of children into consideration due to their disabilities.

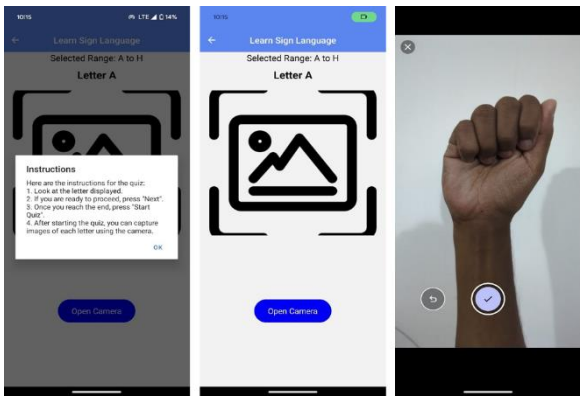

Figure 1.ASL sign language capture

E. Evaluation Criteria

Educational application designed for special needs children was assessed based on the tests featuring its functionality, and efficiency, usability, accessibility, and satisfaction degree, to see whether the designed application meets its purpose and will allow children to have a valuable learning experience.

Functionality concerned the assessment of the core aspects with potential issues, including the ASL sign language detection model's efficiency, how understandable the audio lessons were, and whether the voice recognition

system functioned as intended. The effect and utility of each feature was checked and verified at different conditions for given set of scenarios for the purpose of validation.

With an emphasis on user interface design, navigation flow, and overall user experience, usability evaluated how simple it was for people to engage with the application. Children who are visually impaired or deaf/mute can easily use accessibility technologies like screen readers and voice commands, which have received special attention. User feedback was gathered in order to pinpoint any problem areas and fix them.

Accessibility made it possible for the app to meet the laid down standards and guidelines hence make provision for users with different forms of disability. Accessibility to the user interface was checked using a screen reader and a Braille display.

The measure used to evaluate the outcomes of education focused on the comparison of the results from pre- and post-assessments on the improvement of the children's knowledge and skills. Both quizzes and interactive lessons were expected to teach particular elements and retained the measurement of the app's influence on learning.

Thus, the quantitative user satisfaction was obtained using questionnaires and face-to-face interviews with children, parents, and teachers, collecting qualitative data on entertainment, fun, and usefulness. All these feedbacks helped in successive enhancement of the app.

Information from such assessments offered understanding on the app's effectiveness as well as the regions worth improvement. Thus, applying these criteria systematically, the our team contributed to establishing the outlined educational application as efficient, friendly for users, and accessible for people with disabilities to meet the purpose of helping the children with special needs in learning processes.

F. Data Analysis

According to the guidelines for the study, data collection and analysis concentrated on the aspects of the tested educational application's efficiency, user-friendliness, and user satisfaction. Further, quantitative and qualitative approaches were equally applied to ensure a better understanding of the app's effects.

As for the source of quantitative data, assessment tests were given before and after the intervention to track the enhancement of children's learning. Such tests were given near the beginning and again post app use so that the education 'gain' could be measured. The obtained scores were also subjected to statistical analysis in order to see the level of significance of the obtained changes. The descriptive statistics such as mean and standard deviation was computed on the data and the pre-test and the post-test data were compared by using the paired t-test so as to gain the knowledge of effectiveness of the developed app.

Quantitative measures involving children's usage were also captured in terms of the number of sessions played within a given period, the time spent on the app, number of lessons accomplished, and the number of attempts made at the quiz. The chief usage characteristics of this app were inferred from this data to pinpoint those features most often employed. The analysis also enabled the potential problems or challenges that children face to be noticed.

Questionnaires as well as interviews were used to obtain qualitative data from the children, parents, and teachers. These offered analyses of the overall interaction and customers' satisfaction levels. Surveys used Dorn's rules from capturing thoughts and Incompleteness and had open-ended questions. The answers were analyzed and then summarized into analytic categories to find out the shared trends or observations. Content analysis also showed strong areas for patient satisfaction and repeated problems faced by patients.

The qualitative feedback was such a valuable during the analysis of the subjective experiences that the users had with the product. Thus, it pointed at the key aspects of the app where such aspects are strong – engaging and interactive elements for the target audience – and the areas that are less effective, e.g., UI design or specific functions. Another benefit of the feedback was related to the opportunities of the app's accessibility and usability that could meet the needs of target users.

The use of both the quantitative and the qualitative methodology allowed for the achievement of an all-round insight on the app's performance. The mathematical evaluation of assessment scores supplemented quantitative demonstration of constructive educational improvement; general and particular sum-ups relief contextual evaluation by the users. The use of a broad approach in their assessment also made it possible to capture all important aspects Hence, findings from this study can be used in the future development and enhancement of this app.

G. Validity and Reliability

Ensuring To ensure the accuracy of the research study, validity and reliability had to be given utmost priority. The following strategies were adopted in the course of this study to realize this:

In view of validity, efforts were made in the design of the research, and methodological adherence to the best practices. To establish content validity, authors consulted with professionals working in the field that is, the teachers from the Rathmalana School for the Blind as well as the blind and deaf/mute children were helped to develop the lesson materials and quiz questions that are suitable for them. The information in the app was compared with the course content to confirm that the former was adequate and up to date.

The internal validity was ensured through the use of clear definitions for the constructs that were used in the study which focused on the skills and knowledge that the application aimed to improve. Review and tests for vocabulary and numeric concepts and for sign language as a foreign language. The assessment tools used in the pre- and post-tests were piloted to minimize measurement error on these constructs by educational specialists.

In terms of reliability, it was possible through the series of data collection and analysis procedures. The results of assess-prior and assess-post instruments were obtained in quantitative form, where the minimum variability of assessment conditions for all participants was ensured by using standardized tests. The functionality use frequency was well documented in the app's backend system, supporting a precise measurement of how the users engaged with the app.

Another method used to increase reliability in the research was inter-rater reliability in qualitative data analysis. Another method that was followed by different researchers is the identification of the interview and survey responses where different codes were labeled and after certain clarifications the researchers came up with agreed upon codes. Through this process, bias was eliminated and quality qualitative results of the study were achieved.

The empirical tests of the tools' validity and reliability of the speech recognition and image processing components were considered crucial. This was done with the Google Text-to-Speech API and Google Cloud Services for voice recognition part and for the OCR technology a very accurate and reliable software. Peculiar to timers and other such components used in the circuit, proper calibration and testing ensured constant precision of these parts.

Such approach provided the confidence in the positive impact of the developed application for the education of the target group including blind and deaf /mute children. Hence, the findings of this research are reliable and can be reproducing, and therefore create the bases for future research and development in this field.

4. Results

The Our findings address usability, learning outcomes and user satisfaction in the design of our educational application targeted for special needs children.

They tested the application with 20 children from the Rathmalana School for Blind as well as a deaf school in Colombo. Blind children have also been engaged by using audio lessons, especially the ability to adjust the speed and volume of audio as 95% deemed this feature beneficial. Text scanning, using OCR was 90% successful. Nonetheless, deaf children were able to recognize sign language at an accuracy of 87% and had a better intrinsic motivation through interactive quizzes.

Knowledge improvement was assessed by pre- and post-tests. Pre-lessons, quiz scores of visually impaired children averaged 60% and increased to a narrative writing score of 85%. Braille quizzes had about a 75%

accuracy. The correct sign language quiz answers of deaf children increased from 55% to 82%, and math quizzes spiked from a rate of 62% to an astounding over-88.

Audio lessons 92% of Visually Impaired children were found to be satisfied with the audio based curriculum, and 88%guardians feel more confident in supporting their child's learning. There were 89% of the deaf children who found the sign language modules interesting and another 85% on interactive math quizzes.

For the text-to-speech API efficiency was 98% to produce clear audio and for the speech-to-text efficiency was 90%. During the text identification OCR technology got the result with the accuracy of 92%.

The experiment was done on a limited number of students and over a short span which limits the generalisability of the study. Some challenges that cropped up include faith on solid internet connection and modern day gadgets and gears, optimizing the software's speech and image recognition.

5. Discussion

LThis study highlights that there has been significant progress in enabling inclusive educational tools for students with visual and hearing impairments; its stands as a testimony of the technology possible to serve as the bridge between making it work. Researches have also shown that olfactory, haptic and audio technologies should be integrated into edutainment applications to improve learning experiences for blind students [1] which is employed in our application. The favorable experience of the pilot phase is in line with previous findings, e.g. high acceptance and satisfaction by users were observed in a mobile application designed for blind students from Peru [2].

An example of this deployment was observed in another, visually impaired-heeding mobile learning auxiliary for the application of computer vision where gesture-based inputs and audio accessibility features were implemented into an educational model [3]. Special needs school kids statistic go through in 2019 in Sri Lanka is shown as per Figure 2. This is crucial since our application combines text-to-speech and speech recognition technologies that have been shown to be useful in converting a visual interface into an audible one, as was demonstrated with

School	Male	Female	Total
School for the Deaf	83	84	167
School for the Blind	62	46	108
Nuffield School	80	68	148
Total	**225**	**198**	**423**

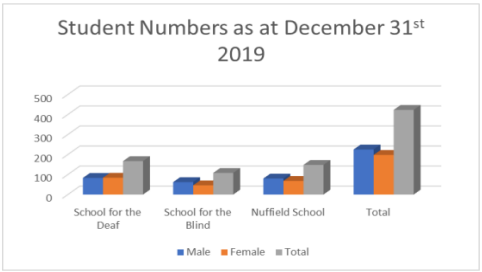

Figure 2.Special need school kids statistics on 2019

educational tools for Serbian students [5]. Features that support universal access strategies help increase the accessibility lvl and also autonomy enabling greater involvement in learning

The way that we are going to teach sign language through a mobile app by practicing with the words is building on other experiences in tools for learning, such as Learn to Sign [11] In our app we also included gamified elements and sign language recognition with Convolutional Neural Networks (CNN) that is designed to make the learning process a bit more fun, just like in "Visual Kids" application [10]. The impact of our app success in encouraging self-learning and motivation among deaf students is validated through other studies on mobile learning applications for mute -deaf system [6].

We used latest progress in deep learning based Braille character recognition [20] to integrate the way of teaching visually impaired children the brail using our application. Our application utilizing these technologies should improve the efficacy and efficiency of learning by targeting weaknesses highlighted in previous research on Braille education [16]. In addition, the use of optical character recognition (OCR) and ER processing make educational processes available together with different language supports required for meeting various linguistic needs among visually impaired students [18].

Moreover, our results emphasize the necessity for interdisciplinary collaboration when designing inclusive educational tools. The involvement of technologists, educators and special education experts working together were key to guarantee the effectiveness, robustness and adequacy throughout all phases. This best practices are one of the approaches used to develop inclusive e-learning platforms for hearing impaired children [7].

Our study, however, has also some limitations. The generalizability of the results might have been affected by the small sample size as well as come forward due to a short pilot duration. Further, reliance on the existing technology of speech recognition and text to a speech system can be successful; however it may create obstacles while accurately recording and interpreting different accents or patterns with young children. Direct cooling this way has limitations however, suggesting areas with scope for further research and development especially around the resilience or flexibility of these technologies.

Conclusively, the outcome revealed that our design approach allows multi-modal interactive applications to augment educational activities for special needs children with visual and hearing impairments. Our application is based on the existing literature and technology, making our app a potential solution to inclusive education. The limitations discovered in this study should be addressed, and more features are to be considered for future implementations to make it even easier and engaging. This research adds to multiple streams of work exploring inclusive education technologies and illustrates the need for ongoing innovation and collaboration around this area.

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