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IMPROVING USABILITY OF THE EDUCABLE OF INTELLECTUAL DISABILITY WITH ASSISTIVE SYSTEM

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ABSTRACT

From the report of World Health Organization (WHO) and World Bank (2011), physically challenged persons carry a significant proportion of the world's population, about 15%, as a result of digital divide between them and the normal individuals, they are rarely seen as a contributor to productive human capital development of the Society. Most of the Intellectually Challenged persons have little or no access to application programs' interfaces, this is as a result of several challenges they face in accessing those interfaces. Most interfaces were developed without considering the fact that, different categories of users including people living with disabilities should be put into consideration during the requirement specification of the system. This paper focuses on the development of assistive system that will promote the user experience of the Educable category of persons living with intellectual challenges and also to compare the degree of efficiency of the assistive model with the existing ones. Theoretical framework on Human computer interaction (HCI) were also carried out and several related articles were reviewed. The design and methodology was based on the data collected from the Department of Special Education in a renowned Federal University in Nigeria. During the process of this research, we discovered that most of the works reviewed did not focus on the usability performance accuracy of systems using acceptable metrics test. The system was designed and implemented using Text / Image enlargement and text-to-speech architecture in C# programming. Concepts of World Wide Web Consortium (W3C), a global centre for web usability design standard and Web Content Accessibility Guide (WACG) for Users with Intellectual Disabilities was employed. The model was tested based on the concept of User Satisfaction / Performance Usability Metrics. The test was carried out on Effectiveness/Efficiency/Analysis of reading Errors, The Mean Percentage, Task Completion (in seconds) were used as the performance measure technique for evaluation. The result showed that the assistive model had a mean percentage performance of 98% and the mean time taken to perform a task in 32secs. The model was successful for the Educable category of people living with intellectual challenges.

Keywords: Accessibility, visually impaired, HCI, usability, Word pad application, browser application, email application, Facebook application

I INTRODUCTION

Most of the Intellectually Challenged users have little or no access to application programs' interfaces, this is as a result of several challenges they face in accessing those interfaces. Most interfaces were developed without looking at the fact

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that, different categories of users including people living with disabilities should be put into consideration during the requirement specification of the system [1] and [2]. The bases of every product are about the usability goals; the study of HCI became the study of Usability, many products that require users to interact with them to carry out their tasks have not necessarily been designed to cater for different categories of users. They may perform their functions effectively from engineering perspectives; but it may be difficult to use most especially by people living with physical challenges. Human-computer interaction (HCI) can be seen as a discipline which is involved with the design, evaluation and implementation of usable products for easy, efficiency, reliable, enjoyable, effortless, and effective to all categories of users [3]. HCI has focused on the need for developing interactive products which will be accessible and usable by every individual including people with Visual impairment, Amputee, Learning disability, and intellectual disability (ID) which is the focus of this paper.. The aim of this research work is to develop assistive model with a combine concept of Text / Image enlargement technology and Text to speech technology for the Intellectually Challenged. According to the tenth revision of the WHO (World Health Organization): Intellectual disability (ID) is a disorder defined by the presence of incomplete or arrested mental development, most especially characterized by the deterioration of concrete functions at each stage of development and that contribute to the entire level of intelligence, such as cognitive, language, motor and socialization functions[4]. From the report of Intellectual Disability Rights Service Inc.[9], Intellectual disability is a disability which happens in the developmental period of life (i.e. before the age of 18) and is shown by below average intellectual functioning.

II Clinical description of intellectually challenged

From the report of Intellectual Disability Rights Service Inc.[5]. Intellectual challenge is a disability which happens in the developmental period of life that is before the age of 18, and is characterised by below average intellectual functioning. Several people with intellectual disability are born with the disability. Significantly sub-average general intellectual functioning is described as approximately 70 IQ or below as measured by a qualified psychological examiner on individually administered, nationally formed standardized measures of intelligence

Clinically, and for the purposes of showing that a person has an intellectual disability, intellectual disability is best assessed by a psychologist as:

a. an IQ of 70 or under, PLUS
b. deficits in at least 2 areas of adaptive behaviour, that is:
    i. Communication
    ii. Self-care
    iii. Home living
    iv. Social skills
    v. Self-direction
    vi. Leisure and work
    vii. Learning.

In clinical terms, intellectual disability is usually defined in terms of the severity of the disability.

Table 1 Clinical description of intellectually challenged

Level of disability	% of people with intellectual disability	IQ
BORDERLINE		70-75
MILD (Educable)	75%	55-70
MODERATE (Trainable)	20%	30-55
SEVERE (Totally dependent)	5%	under 30

Source: (IDRS Inc. 2009)

People with intellectual disability have little or no access to computer and Internet based on the following reasons:

i. the tools are cluster and difficult for them to access
ii. the images / pictures of the tools are too small to study and understand
iii. the Text are too small and cluster to study and comprehend

III RELATED WORKS

Andrew [6] worked on Co-Designing with Young Adults with Intellectual Disability to Develop Social Life Skills, The research established itself in social inclusion, and in exploring how existing competencies with technology and interests associated through technology can be leveraged to encourage social skills development and participation. With this approach, the aim of the work is to establish how technologies are suitable,

neglected, and how they might be re-designed and rebuild while focusing on supporting social participation for young adults with ID. The research employed a Participatory process Research Approach that make use of qualitative methods and co-design workshops. From the research, the first study was conducted. The study analysed social media participation among young adults with ID through four social media sites (Facebook, YouTube, Instagram and Snapchat). The findings showed different participation through the sites, with all 27 participants involved in the research participating in YouTube. From the findings, it was conclude that social inclusive and use of social media contribute different potentials to the Intellectual disabled user. There is also a possibility for social media to be balanced to support-developing participant's social participation skills and ability.

Ojuope and Adetunmbi [7] worked on Empowerment of Persons with Intellectual Challenges for sustainable Development. The aim of this paper is empowering individuals living with Intellectual disability and build the skills necessary to ensure that human empowerment is an advantage to achieve a sustainable development goals. Nigeria in recent time have been threatened with alarming scenario as a result of unemployment which resultant effects ranges from extreme poverty, hunger to insecurity. Consequently, the application of Information and Communication Technology have not be vigorously harnessed to its fullest despite its perceived vocational and wealth creation opportunities. Nigeria is the most populous state in Africa, The increase in population without availability of resources to manage this growth has become a worry to Nigerian citizens. Hundreds of Thousands of people living with disability are without any hope for the future. The advent of Information Technology has brought about various opportunities including job creation, business strategy and planning etc. Information Technology is the bedrock for economic survival and development in a rapidly changing global economy. The availability and the use of information technology are prerequisite for economic and social development in our world. This paper aims to provide concrete suggestions on how to advance the empowerment of persons with intellectual disabilities and their representative organizations to enhance poverty reduction and promote sustainable development.

Dany *et. al.,* [8] worked on "Bridging the digital divide for people with intellectual disability (ID)". Data collected recently from several studies and surveys confirm that our society has entered the digital and information age. It was discussed by some authors that information and communication technologies (ICT) have the potential to promote people's power to act and encourage equal citizen participation. These elements are particularly essential for individuals living with intellectual disability (ID). Although, it seems that the use of ICT is challenging for these categories of users and that a digital divide has gradually formed between them and the connected citizen. The general objective of this theoretical article is to identify and illustrate the dimensions that must be considered to promote the digital participation of people with ID.

Rabbia and Seemab [9] worked on "A Mobile Application to Improve Learning Performance of Dyslexic Children with Writing Difficulties". From the work, learning disabilities can be referred to as ay hidden disabilities that affect several individuals with average or above average intelligence throughout their life Pirani (2012) and Edyburn (2006) stated that the cognitive ability (intellectual ability, attention deficits, memory, and thinking skills) and academic ability (reading, writing, language arts, and mathematics) of a person are associated with several categories of learning disabilities. The paper aim at developing a Mobile Application to Improve Learning Performance of Dyslexic Children with Writing Difficulties.

Doris *et. al.,* [10] worked on "Usability Testing in Mobile Applications involving people with Down syndrome: A Literature Review". The work described Usability as a quality attribute of interactive systems defined by five attributes: learnability, efficiency, memorability, errors and satisfaction. In ISO 9241-11. Usability is one of the key ingredients needed by a product or system. Down syndrome (DS) is a genetic disorder with a worldwide incidence close to one in every 700 births (15/10,000), but the risk varies with the mother's age. A usability testing methodology appropriate for participants including people living with DS should be thoroughly designed. In everyday life, users are involved in systems carry sensitive data. There is need for adequate security measure for the modern software applications. This unsecured platforms can be referred to as 'untrusted clients'. As internet usage grows rapidly grown over the years and, more users are exposing their information system to their clientele, it is very expedient to understand users' data that need protecting and to control system access as well as the rights of users of the system.

Zehra *et. al.* [11] worked on "The Role of Social Media Tools: Accessible Tourism for Disabled Citizens". Information and technology becomes bridge to promote usability, accessibility, user experience and equality of the citizens. There is an increasing need by the society to gain services for accessibility to the travel and tourism opportunities and this requires information, effort and desire. Particularly, people with disabilities need easy access that will help them to live their lives in equality and usability standards. Travel is a key for promoting globalization to acquire information for the development. Activities of Tourism in the societies contribute heavily in providing accessibility and widening accessibility for all citizens. For the wellbeing of the society, accessibility is an important element for the disabled citizens where literature pays attention on physical and web accessibility for societal and institutional services. This research study aims to evaluate the role of social media tools on tourism services in relation to the perceptions of disabled people.

Omowumi *et. al.* [12] worked on Usability and Accessibility enrichment e-mail application system for the visually impaired. A text to speech synthesizer was used to translate mail content to a speech output during the system design and implementation. And the concept of World Wide Web Consortium (W3C) accessibility guidelines was employed as a framework in developing usability system. Microsoft Visual Studio was used as the Integrated Development Environment (IDE). C# was used as the programming language following the guidelines of W3C. Accessibility library, system speech library was implemented and used to design a friendly and usable email application interface for visually impaired user. The Email application system was tested and evaluated by comparing it with other desktop email application (Microsoft outlook and Mozilla) in relation to visually impaired users.

Ojuope and Adeyemo [13] worked on "Comparative study of the usability and accessibility assistive Interface for the intellectual disability users". The paper focuses on the comparative study of the usability and accessibility satisfaction they also compare the degree of efficiency of assistive Interface with the existing interfaces for intellectual disability users. During the process of the research, it6 was discovered that most of the work reviewed did not focus on evaluating user satisfaction and degree of efficiency of user interface using acceptable usability metrics test. The user model was tested based on the concept of User Satisfaction Performance Usability Metrics to test Satisfaction with the developed application. From the mean score of the participants, the result showed that the participants expressed their 98.6% satisfaction with the new assistive model and expressed their 78.4% frustration (Dissatisfaction) with the existing applications the degree of satisfaction of the participants with the interface was high and successful.

Critina *et. al.* [14] worked on user experience to improve the usability of a vision-based interface. Traditional software engineering process was used to develop the hand-free interface for motor-disabled users, in particular, the system was developed following a prototyping models to comply with Gould and Lewis (1985) principles when designing for usability: early focus on users and tasks, empirical and experimental studies with simultaneous or prototypes and interactive design were carried out. Special attention was paid to satisfaction and fatigue information. The therapists observed that the user's mental and physical state on a particular day affected task performance strongly. Therefore, studying fatigue and satisfaction is very important.

Daniel *et. al.* [15] worked on enhancing independent access for individuals with mental retardation through use of a specialized web browser: A pilot study. In this pilot study a prototype web browser called web trek that utilizes multimedia to provide access for individuals with cognitive disabilities was developed and pilot-tested. Participations were recruited from an agency providing services to people with mental retardation in Colorado Springs school district. Twelve individuals with mental retardation participated in the study. Internet explorer and web Trek were the two browsers used. The three tasks performed with each browser involved searching for web sites, saving web sites to a favourites list and retrieving saved sites from the favourites list. All the participants formed one group and Test was carried out within one hour. A one-tailed student's t-test for identifying mean differences with paired examples was used. Overall results of the work provide preliminary evidence that the web Trek browser provided better access to the internet for individuals with mental retardation than did a widely available web browser (internet explorer).

Muktikanta and Angeline [16] worked on making web application operable by physically and mentally challenged users. The research work addresses some key recommendations of WCAG 2.0 and how to write code which is compliant with the guidelines.

For example, when a site is coded with semantically meaningful HTML, with textual equivalents, provided for images and with links named meaningfully, many users who have disabilities need more time to complete tasks than the majority of users. These kinds of users should be provided with enough time to read and use content. It was concluded that the basic concept behind web site operability is that everybody should be able to use the tools and mechanisms required to operate the web site.

Oksama [17] Worked on the peculiar features of training program interface design developing for children with mental retardation. Recent changes in the system of preschool education affected the content of remedial developmental education of children with intellectual disability. The ability of computer to produce the information simultaneously in the form of text, graphic images, sound, and voice, video to remember and to process data with great speed allows data to be processed with great speed, which will allow the development of multimedia training programs for children with intellectual disability.

IV RESEARCH GAP

Several related articles were reviewed on this paper, and we discovered that:

i. .Most of the reviewed works on the area of Intellectual Disability did not address the use of text to Speech and Text/Image enlargement.
ii. Most of them did not use usability performance metrics test.

V METHODOLOGY

This section analysed the difficulties faced by the intellectually challenged persons in accessing job and Information Technology device. From the research carried out by the author of this paper in Home School for Handicapped Children, Ibadan, Oyo State in 2018, It was discovered that, these people have little or no access to computer and IT facilities due to the clustering of the Application tools. So they find it difficult to learn and comprehend. Users with intellectual disability have problem with navigating around applications, either due to the fact that:

a. the tools are cluster and difficult to access
b. the images / pictures of the tools are too small to understand
c. the Text are not easy to memorise; and
d. the Text are too small to learn and comprehend.

Developing assistive systems for these people becomes imperative, this will enhance digital inclusion of these people and further promote job creation.

Intellectual disabilities is significantly sub-average general intellectual functioning which exists simultaneously with deficits in adaptive behaviour that adversely affects educational performance and originates before age 18. Intellectual disability does not include conditions primarily due to a sensory or physical impairment, Amyotrophic lateral Sclerosis (ALS), traumatic brain injury, autism spectrum disorders, severe multiple impairments, cultural influences or a history of inconsistent and/or inadequate educational programming [5].

The problems of the existing applications for persons with intellectual disability are:

a. Navigation around the user interface: users with intellectual disability have problem with navigating around applications, either due the fact that:
    i. the tools are cluster and difficult to access
    ii. the images / pictures of the tools are too small to understand
    iii. the Text are not easy to memorise
    iv. the Text are too small to learn and comprehend
b. Poor interface: Some computer / Internet application interface are very frustrating, with the arrangement and distribution of tools.

The contributions and solutions to individual problems are:

i. Text / Image enlargement interface tools to enhance Intellectual Challenge learning ability.
ii. Text-to-speech(TTS) model to increase the degree of comprehension,
iii. Using few menu and tools that can perform specific tasks, this will reduce time spent to access application tools

Basic Components of the assistive model

i. Create new document
ii. Save document
iii. Retrieve / open document
iv. Print document
v. Search for web sites
vi. Exit applications

Create new document
Creating new document in Microsoft word or other word processing application is a an easy task. To create a new blank document, click the Microsoft office button, select new, the new document dialog box appears, select blank document under the blank and recent selection. It will be highlighted by default, click create. A new blank document appears in the word window

Save document
While you are creating a document, it is important to save it for future use. The saved document now becomes a file. A file is a complete, named collection of information, such as a user-created document. It is a basic unit of storage that enables a computer to one set of information from another. It is a collection of data a user can retrieve, change, delete, save or send to an output device, such as printer or e-mail program. To save document in word processing, click the Microsoft office button and then click Save As, type the file name and in the Save files in this format box, click the file format that you want to use then next to the Default file location box, click Browse, and then click the folder where you want to save your files. Finally, click Save.

Retrieve / open document
A saved document can be retrieved, viewed and reused. Here are the steps involved in opening/retrieving a saved document/file in word environment. Click the Microsoft office button and then open, in the look in list, click the drive or folder that contains the file you want to open. Click the file, you will see a preview of the selected file in the preview box then click open.

Print document
To print document click the File tab, and then click print, then choose the part of the document to be printed, select the printer and paper type and paper orientation then click print.

Search for web sites
To search for website, you must use a search engine; Search engine make it very easy for you to find a website. In fact, most web browsers have a search engine input field built in so you don't even have to go to the search engine home page in order to do your search. Just type in in the term you are looking for in your browser's input field and you will be taken to a search results page, where you can pick the most relevant result for your query.

Exit applications
To exit any application, click the Close (x) button or choose File, then click Exit

Text / Image enlargement: Concept for accessibility for user with intellectual disability
It was discovered that Persons with intellectual disability have little or no access to computer and internet facilities. This is due to the size and the complexity of the tools of most of the applications. The bigger the interface tools the higher the efficiency of its usability. Due to this fact, Text / Image enlargement and Text to speech will be used to support the assistive interface developed in this research work.

The basic concept of text / Image enlargement
Text / Image enlargement is a good interface magnifier that gives positive computer access solution that will create effective accessibility for users with intellectual disability. The software contains two adaptive technologies—screen magnification and screen reading. Text/Image enlargement allows you to see and hear everything on your computer screen, providing complete access to applications, documents, email, and the Internet.

The concept of Text to Speech for interface accessibility
The process of digitization starts with the book being scanned page by page. Thus a digitized book is a series of images where each image equivalent to a page in the book. Each digitized page is processed with the use of Optical Character Recognition (OCR) to acquire text in ASCII or Unicode format. The digitized text is stored in the UDL (National centre on Universal Design for Learning) portal. By a request from the user, this text is sent to a text to speech (TTS) system for conversion into a speech signal,

Word processing application
A word processor is a computer program used to create and print text documents that might otherwise be prepared on a typewriter. The key advantage of a word processor is its ability to make changes easily, such as correcting spelling, adding, and deleting, formatting and relocating text [18]. The system will perform the following functions: Create new document, save document, Retrieve / open document, Print document and open web browser

Reference Architecture for the Web Browser
The web browser is perhaps the most widely used software application in history. The browser will perform the following tasks: Search for web sites, Saving web page, Retrieving saved pages, Print web

page and also provide access to other internet facilities such as e-mail and Facebook.

Architecture of Image / Text Enlargement for the applications

Figure 1 shows the architecture of the image / Text enlargement for the applications

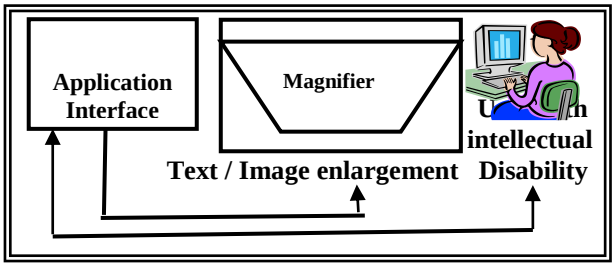

Figure 1 Architecture of Image / Text Enlargement for the applications

Components of the Assistive system

Figure 2 shows the relational diagram for the functionality of the applications for the users with intellectual disability.

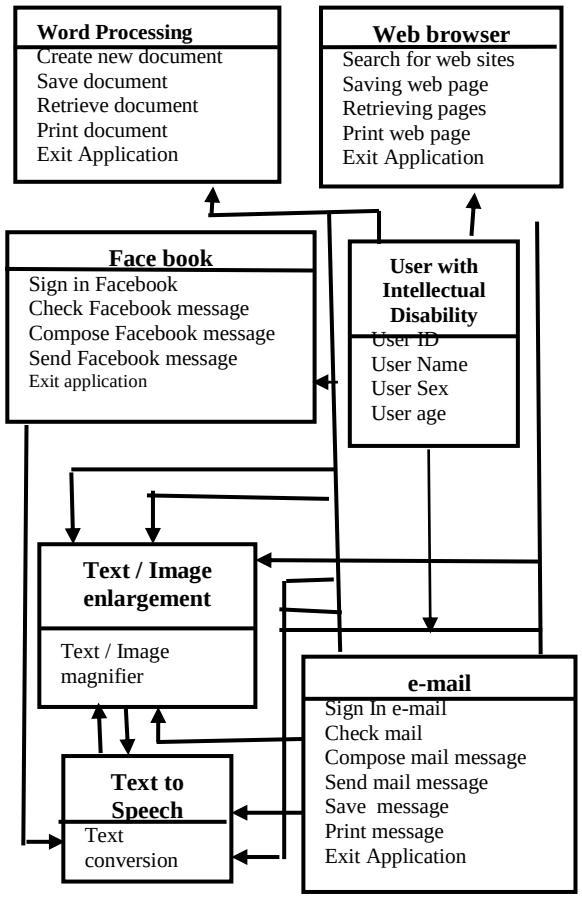

Figure 2. Relational diagrams for the functionality of the model.

Data flow diagram for a text to speech system for the applications.

Figure 3 shows Data flow diagram for a text to speech system for the proposed applications.

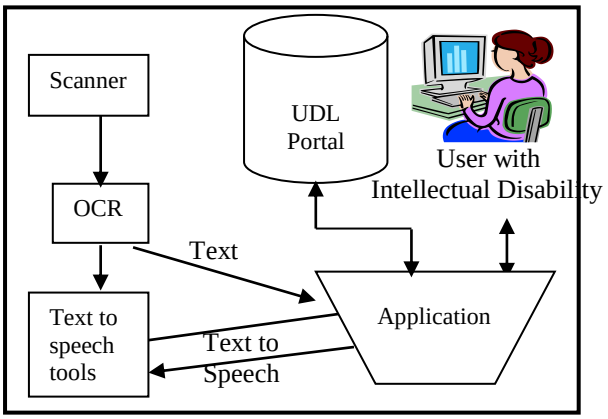

Figure 3 UDL diagram for a text to speech system for the applications.

VI Implementation

System implementation is the construction of the new system and the delivery of that system into production (that is day-to-day business or organization operation. It is the process of defining how the information system should be built (i.e., physical system design), ensuring that the information system is operational and used.

4.1.1 Word Pad (Word Processing) for Intellectual Disability

Fig. 4. Developed Word Pad (Word Processing) for Intellectual Disability

The simple word pad has tabs for create new document, save document, open document, print document and browser. From the browser, the user can have access to the web browser. There are also tools like bold, underline, italics and font type.

Web Browser for Intellectual disability

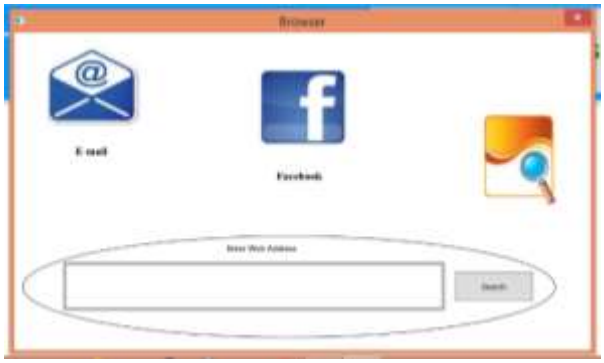

Fig. 5. Web Browser for Intellectual disability

The browser has a web Address where the user can enter the web address to search, and search tab where the user can click to start searching. It also has E-mail and Facebook tabs where the users have direct access to sign in and open e-mail and Facebook respectively.

System Testing

The test was conducted based on the concept of Accessible Website Content Guidelines for Users with Intellectual Disabilities [19]. Parametric ANOVAs (Analysis of Variance) were applied, with the use of T-Test. The test assesses whether the means of two groups are statistically different from each other.

VII RESULTS

Efficiency in seeking information

As a measure of efficiency, the time needed for finding the correct information for each task was measured. However, the assistance that was offered to participants who could not find the requested information did interfere with time measurements, especially, the participants that used Non-Assistive Applications had difficulties in finding the information. The needed assistance in 3 (out of 4) tasks, participants that used Assistive applications needed assistance, in few cases, one or two times. The participants using NA-Application needed assistance on average of 33.25 times while the participants that used A-Application needed less assistance on average of 19.25 times with the difference of 14, $P<0.005$; this is statistically very significant; as shown by the results of a parametric two-way anova. The assistance needed was influenced by the version of the application, as the anova showed $[F(1,36) > 1]$.

Satisfaction with the application

The satisfaction of the participants with the versions of the applications was tested by asking them to express their opinions on a 15-item questionnaire. The mean scores of the participants were taken with the use of a rating scale. The participants used NA Application had mean score of 1.08 and the participants used A Application had the mean score of 4.95, the difference in mean score is 3.87 and the difference in the SD is 0.099. This is statistically significant. The questions were used to compare the satisfaction of the participants with the versions of the applications. The participants used A Applications expressed their 98.6% satisfaction with the applications while the participants used NA Application expressed their 78.4% frustration (Dissatisfaction) with the applications. All the Participants preferred the A Applications.

VIII CONCLUSION

In conclusion, the usability performance metrics test used to measure the performance accuracy of the system during the system testing shows that the objectives of this work have been met in promoting the user experience of the Intellectually Challenged persons. The degree of satisfaction with the assistive system compared with the existing system, the result showed that the participants expressed their 98.6% satisfaction with the new assistive model and expressed their 78.4% frustration (Dissatisfaction) with the existing applications. The degree of satisfaction of the participants with the new system was high and successful. The model recorded high accuracy.

XI Recommendation for future work

The following recommendations were made to assist the users with intellectual disability.

I. It was recommended that all software developers should always consider the users with intellectual disability while developing interactive applications meant for all users. All software being developed shouldn't be restricted to users without any disability alone; all other users should be considered.

II. All software development meant for users with intellectual disability should make sure they follow the Web Content Accessibility Guide (WACG) for Users with Intellectual Disabilities by Joyce (Karreman, 2007), and W3C guidelines stated for developing application software and make sure all the applications developed meet the standard specification stated by W3C.

III. More assistive tools and device should be in incurred to enhance the interactivity and work rate of the users.

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