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Extended Human Computer Interaction (HCI) Model for People with Visual Impairment in Education System; A Case of HVP Gatagara, Rwanda

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Abstract:- Human Computer Interaction (HCI) is the study of how people interact with computers. Researchers in the field of HCI both observe the ways in which humans interact with computers and design technologies that let humans interact with computers in novel ways. The main problem investigated in this study was that present computers and systems are not very convenient for visually impaired people. There was no translator for blind people translating in their local language, no recording options, poor speech synthesizer as well as screen reader. The general purpose of this study was to design an enhanced Human Computer Interaction (HCI) model for people with visual impairment for better access to education system in Rwanda through screen reading. The study investigated the effects of screen readers, speech synthetizers, sound captures, and refreshable keyboards on an enhanced human computer interaction (hci) model for people with visual impairment in education system. The study found out that screen readers yielded a FL= 0.02 in the extended HCI model for V. I, speech synthetizers yielded FL= 0.06, sound captures yielded FL= -0.03, and refreshable keyboards yielded FL= -0.01, and have a significant effect on visually impaired end-users. The study has confirmed that the model, after testing Goodness-of-fit Index, was on overall the best in terms of model fit. This study has proposed and recommended using this extended human computer interaction model for people with visual impairment in Rwanda in order to effectively serve the Rwandan citizens with visual impairment problem towards their satisfaction.

Keywords*: visually impaired; database; blind people; Human computer interaction; screen readers; speech synthetizers; sound captures; refreshable keyboards.*

I. INTRODUCTION

Rwandans with disabilities, like other communities in the subregion, continue to face educational marginalization and exclusion (Charlton, 2000; EENET, 2003; Vaneste, 1997). One obvious indicator is their under-representation in education and professional training, and thus in the labor force. Recent socio-political changes in Rwanda appear to be improving the situation in Rwanda. B. Despite passing laws and policies that encourage different levels of participation in decision-making and respect their place in Rwandan society, their general lack of education and training leads to a vicious cycle of exclusion, dependence and poverty. Based on the derogatory terminology still used against the disabled in the local media, languages and cultural concepts it cannot be ruled out that some of the Rwandan communities still regard them as equal members of the society (Karangwa, Ghesquiere&Devlieger, 2007). Article 40 of the National Constitution of June 2003 states that "everyone has the right to education" and further states that "the State shall take special measures to promote the education of persons with disabilities. Equally vainly, the education sector policy pointed out in the same year: In particular, the disabled, orphans, street children, and head of family children represent particularly vulnerable groups who 2wever blind people have no such accessibility mechanisms that can bring them apart from the normal users. So technologies that could help visually impaired people to contribute more in the workplace and improve their quality of life are surely welcome. (Belton, 2016).

II. BACKGROUND

The concept of designing technologies for people with visual impairment was introduced in the Human-Computer Interaction (HCI) literature at the end of the nineties, following a series of research. It is estimated that 15 percent of the world's population, around one billion people live with visual impairment, so even if you don't have an impairment yourself, you are likely to have a friend, a family member who has (Richardson, 2017).

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III. LITERATURE

A. Concept of Sound Recorder (SR)

Sound recorder is another means for a student who is blind or visually impaired to access information. These devices can help a student access information easily. These technologies can make it easier for a student to access information. Remember that aural skills should be used with print or braille training or instruction. All students should be given the opportunity to be educated in the best possible way, and this should not be limited to access by personnel who can adequately teach them**.** (Lemmetty, 2017).

B. Concept of Speech Synthesizer (SS)

Speech synthesis means conversion of written text into spoken words by concatenating speech waveforms (Lemmetty, 2017). Speech is the most natural way for two or more people to communicate. Clarity of voice and pronunciation are crucial factors in delivering the message accurately in effective communication expressions. Because different people have varied qualities such as pitch, prosody, accent, and pronunciation, it is difficult to follow conventional speech characteristics over the world. Even the individual's speech is full of variations depending upon his mood, biological fitness, and different state of mind (Acero, 2007).

C. Concept of Sound Capture (SC)

The sound capture is a computer-based multifunction audio testing system that may be used to design, verify, and test audio components like loudspeakers, acoustics, and audio electronics. Capture complex frequency responses by applying full-length sequential stimulus, swept tones, gated sine, or multitones to your device under test or acoustic environment**.** (Acero, 2007).

D. Concept of Refreshable Keyboard (RK)

Braille displays electronically raise and lower different combinations of pins in braille cells to enable access to information on a computer screen. The braille display can display up to 80 characters on the screen and is updateable. This means that the braille display changes as the user moves the pointer around the screen using command keys, cursor routing keys, or window and screen reader commands. Braille displays are located on the user's desk, often under the computer keyboard. The advantages of braille display over synthetic speech include direct access to information, the ability to examine format, spacing, and spelling, and the fact that they are quiet. (Acero, 2007).

E. Proposed HCI MODEL

Some problems found in the existing human computer interaction for people with visual impairment will be solved by introducing new tools that a researcher has to use referring to the existing system. The newly added technologies include the following: (a) An option to record the screen reader as the tasks are being given so to allow a visually impaired student to use playback to understand more the task; (b) Amelioration of the speech synthetization method; (c) Translator for blind people translating in a given local language has been added.

a) Tier 1: Input as task to student

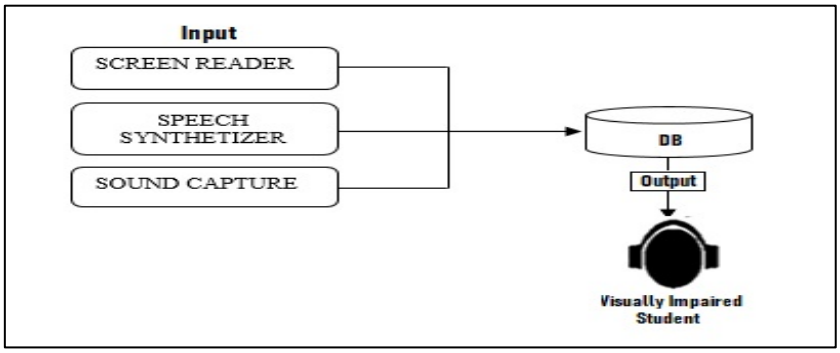

Fig. 1: Input as task to student

A teacher will be able to create a task using either a screen reader or speech synthetizer or sound capture as input that will be stored into database after being processed. The stored is an output that a blind student will access as the task given by the teacher. For these added tools, a researcher will come up with an improved human computer interaction model for people with visual impairment grace to the improved input.

b) Tier 2: External variables and TAM

In this tier, there are three external variables with different indicators: screen reader, speech synthesizer, and sound capture. External variables are defined as factors that are not manipulated as part of the experiment, but may influence the dependent variable under study. Each external variable is directly linked to TAM's perceived usefulness as well as perceived ease of use for measuring their usefulness and ease of use for how they will affect users once the system is out, as shown in figure below.

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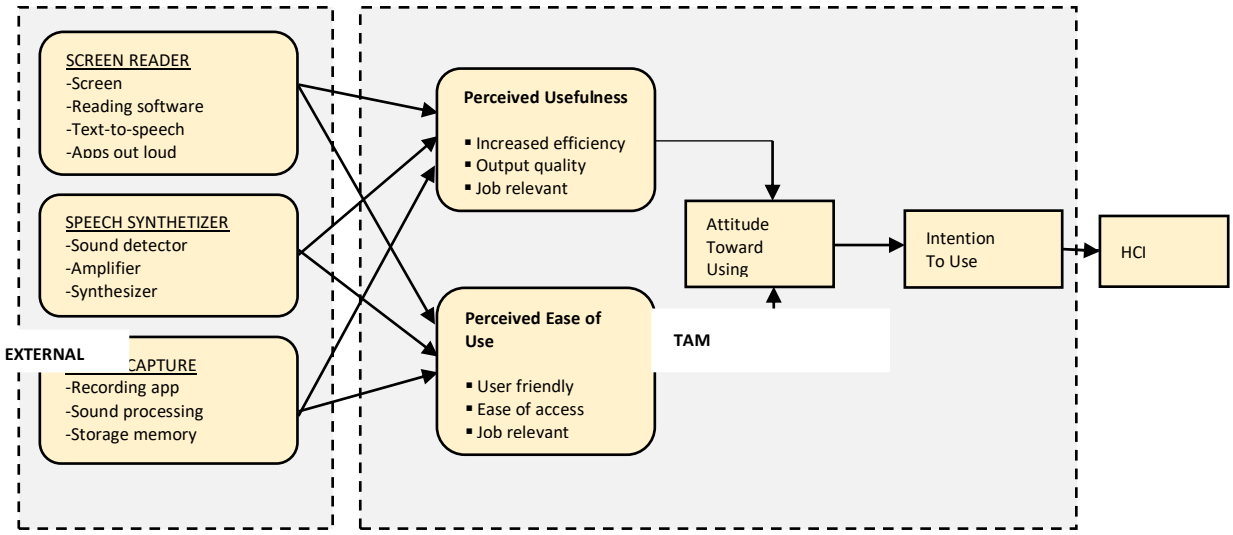

Fig. 2: External variables and TAM

Source: Own drawing

c) Tier 3: Task preparation

The prepared task, either audio or braille's tactile information have to be recorded and then stored within a database for future use by the user of the system especially when there is a need to make a playback of task given. For all this process to be successful, the system is required to be connected to the internet and the later must be secured.

The created tasks will be transferred to the users of the system through the network. What a user shall do is to be connected to a network for accessing the database in which all the tasks are stored. By the same means, the user shall submit the task to the instructor through the network.

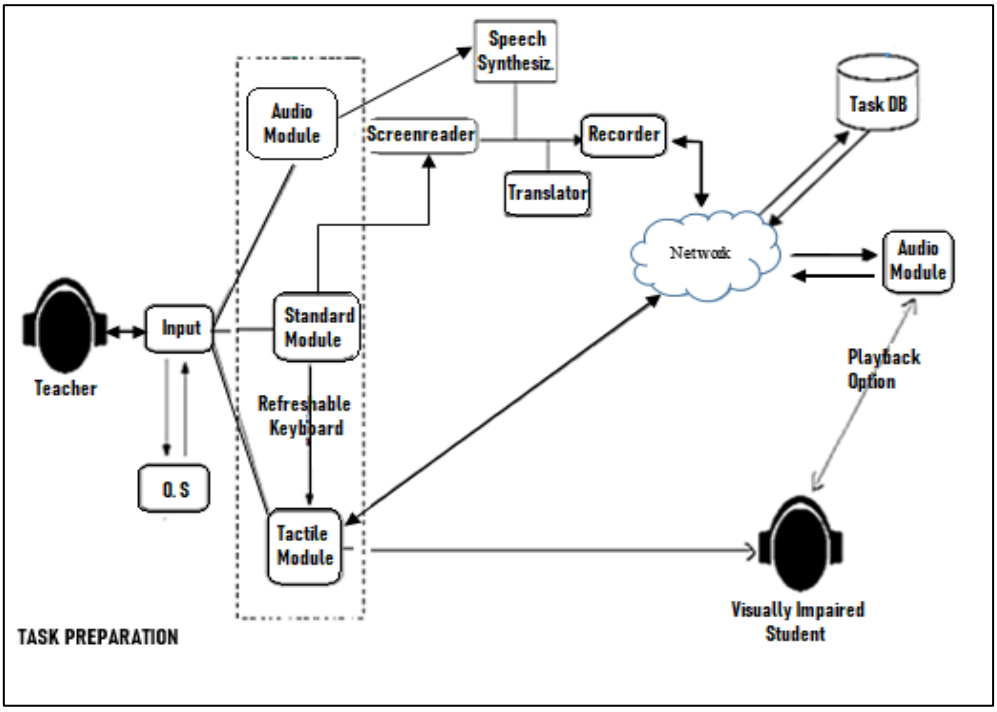

Fig. 3: Task preparation

Source: Own drawing

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d) Tier 4: Compiled HCI model

In the compiled new HCI model, there will be a link between a teacher and a blind student through the connection established between them. Teacher prepares and delivers tasks to the blind students via a secure network. All prepared tasks have to be firstly recorded and then stored in a database before being shared among blind students who will access them by connecting to the database through a network. In return, students will send back their work in the database where a teacher is able to fetch them for correction. In this model, both database and network must be secured to prevent any intrusion or third party who might disclose the data.

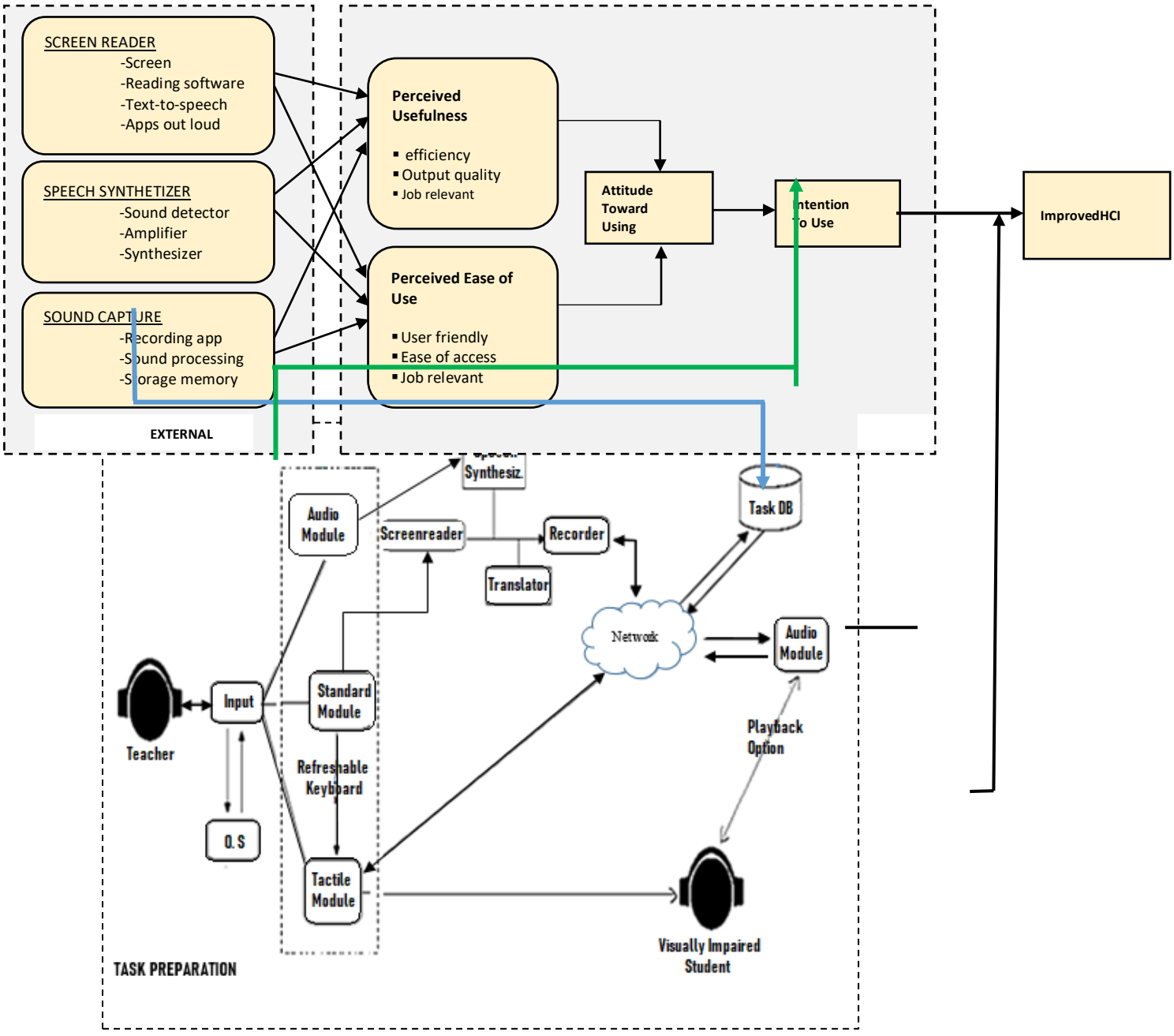

Fig. 4: Addyl_HCI MODEL

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IV. METHODOLOGY

The approach for systematically solving a research problem is known as research methodology. "When we talk about why a research study was performed, how the research problem was identified, how and why the research question was formulated, what data was collected and what method was utilized, why a certain approach of data analysis was chosen, and a host of other questions are frequently answered." (Sam, 2012).

A. Data analysis and tools

Data analysis is a process of developing answers through examination and interpretation. Data analysis is essential for understanding results from surveys, administrative sources; for providing information on data. Data analysis in expected to provide enlightenment to the topic under study and respondents perception but also to enrich readers' knowledge on the topic under study and feeding their curiosity in this area of the study.

This study will use Analyzed of Moment Structures (AMOS) developed by James Arbuckle in 1979. It implements the general approach to data analysis known as structural equation modeling (SEM) which is a multivariate analysis technique that encompasses standard methods such as multiple regression and conventional techniques like general linear model, common factor analysis, variances and covariance (Arbuckle, 2007). This study preferred to use AMOS, since it accepts data analysis and drag-and-drop drawing tools. The AMOS graphic interface is very important in this study to present the results from analyses in a visual framework that is very easy to understand. The SPSS software will also be used to produce graphs for interpreted data.

V. FINDINGS

A. Results of model testing by AMOS

SEM was used in this study because it provides a clear Analyzing and conceptualization of the study, allowing the researcher to test a set of regression equations at the same time (Cathy, 2016). Model fit is related to data, model, and estimation methodology, and over the years, a plethora of fit indices have been developed. Fitting is an automatic process that ensures your machine learning models have the individual parameters that are best suited to solving your specific real-world business problem with high accuracy (Correira, 2018).

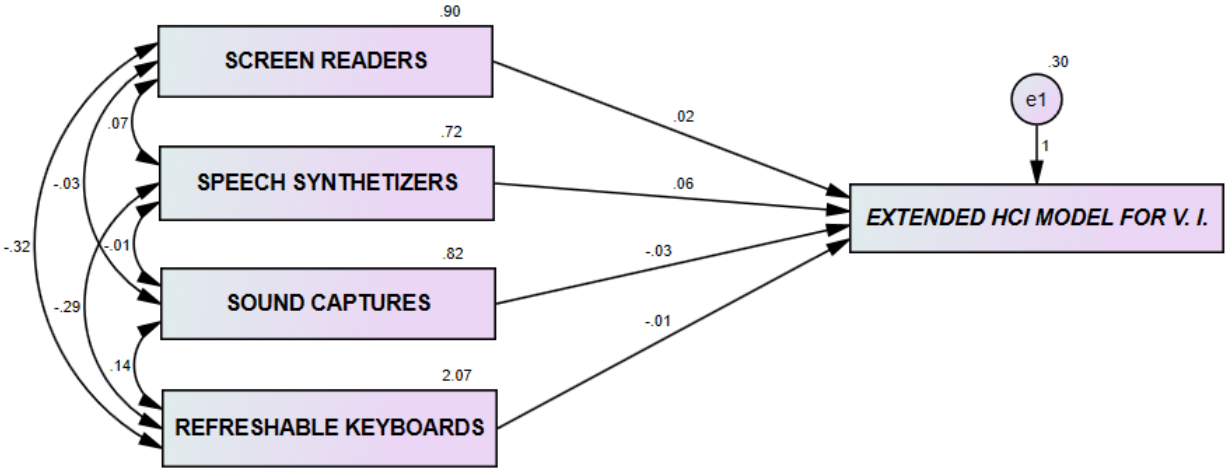

Fig. 5: model testing by AMOS

B. Results of model analysis

The correlation between the original variables and the factors is referred to as factor loading (Correira, 2018). According to the above Figure, in the extended HCI model for V. I, the predictor of screen readers yielded a FL= 0.02; speech synthetizers yielded a FL= 0.06; sound captures yielded a FL= -0.03, and refreshable keyboards yielded a FL= -0.01.

A well-fitted model yields more accurate results. Once a model has converged and parameter estimates have been presented, the question is whether the empirical data fit the proposed model to a large extent. In other words, how well the data's correlation or covariance matrix matches the matrix implied by the model (Cathy, 2016).

C. Structural model Fit Indices

The structural model fit is checked based on Chi-square (x^2), Degrees of freedom (Df), p-value, x^2/df, Goodness of Fit (GFI), Normed Fit Index (NFI), Relative Fit Index (RFI), Comparative Fit Index (CFI), Tucker Lewis Index (TLI), Incremental fit index (IFI) and Root Mean square of approximation (RMSEA). The Model fit indices for the constructs have been found and the summary of the result is shown in the Table where the obtained Model fit indices are compared with the recommended value.

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Fit statistic	Recommended Level	Results	Comment
X^2	-	X^2 = 24.164	Standard
Df	-	Df = 10	Standard
X^2 significance (P)	p < = 0.05	P= 0.03 <0.05	Significant
X^2/df	< 5.0	2.416	Good
GFI	> 0.90	0.943	Good fit
NFI	> 0.90	1.000	Good fit
RFI	> 0.90	.000	Not Good fit
CFI	> 0.90	1.000	Good fit
TLI	> 0.90	.000	Not Good fit
IFI	> 0.90	1.000	Good fit
RMSEA	< 0.05	0.091	Not Good fit

Table : Fit statistics of the Measurement model

Results obtained goodness of fit indices are all presented. The model has yielded the following results: value of X^2= 24.164, Df = 10, p = 0.03, X^2/Df = 2.416 less than 5 hence better fit, GFI = 0.943 > 0.90 hence better fit, NFI = 1.00 > 0.90 hence better fit, RFI = 0.00 < 0.90 hence not good fit, CFI = 1.00 since > 0.9 it better fit, TLI = 0.00 < 0.90 hence not good fit, IFI = 1.00 > 0.90 hence better fit, and RMSEA = 0.14 since value of <0.05 is of good fit, according to rule of thumb : a value of the RMSEA of about 0.05 or less would indicate a close fit of the model in relation to the degrees of freedom results that the RMSEA is equal to 0.091 (<0.05 is acceptable) (Arbuckle, 2007) hence not good fit. Confirming that the model after testing Goodness-of-fit Index was on overall the best in terms of model fit, results were in agreement with (Arbuckle, 2007).

VI. CONCLUSION

The important purpose of this study was about designing an extended human computer interaction (hci) model for people with visual impairment in education system; a case of HVP Gatagara, Rwanda. This studypresentedan assortmentoffindings startwithdemographicfindings.The study found that themajority(67.8%)of therespondentsweremale, 30% were Inclusive Education Officers, 40.9%of respondents had between 0 and 3 years of experience, and 76.1% of respondents had bachelor level of education.

Furthermore,thestudy investigatedtheeffects of screen readers, speech synthetizers, sound captures, andrefreshable keyboardsonan enhanced human computer interaction (hci) model for people with visual impairment in education system.Thestudyfoundoutthatscreen readers yielded a FL= 0.02 in the extended HCI model for V. I, speech synthesizers yielded FL= 0.06, sound captures yielded FL= -0.03, and refreshable keyboards yielded FL= -0.01, and haveasignificant effect on visually impaired end-users. The study has confirmed that the model, after testing Goodness-of-fit Index, was on overall the best in terms of model fit.

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