Human-Computer User Interface Design for Semiliterate and Illiterate Users

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ABSTRACT

Information and Communication Technology (ICT) has revolutionized the lives of the people. The technology is embedded in daily life of literate or semiliterate/illiterate users. However, the user interface (UI) requirements for semiliterate/illiterate users are different from that of an educated person. The researchers of Human Computer Interaction for Development (HCI4D) face challenges to improve the usability of a UI for the semiliterate users. Therefore, a Systematic Literature Review (SLR) is conducted to provide a set of design factors and guidelines for UI development of semiliterate users. The study is based on extensive research gathered from literature to understand the user-centered design (UCD) approach, enhancing user experience (UX) for semiliterate users. This study analyses fifty two research articles that are published during 2010-2020. The findings shed light on the systematization of UI design guidelines for semiliterate/illiterate users. These guidelines can help in taking advantage of ICT during the COVID-19 pandemic. The analysis shows that seventeen main design factors are indispensable for designing UI of semiliterate users. The most suggested design factors include localization and graphics, which should be incorporated in UI for the target population. Moreover, the lag in the design factors as personalization and consistency open a road for future research.

Keywords: Human Computer Interaction; information and communication technology; design factors; semiliterate; user interface; user experience.

1. INTRODUCTION

ICT is a branch of Information Technology (IT) which integrates devices like laptops, PCs, wireless devices, and hardware for providing connectivity to users. ICT has transformed the world. It offers people with the facilities of E-Banking, E-government, E-Health, and many services to augment the quality of life. Therefore, many entities with a global development focus have turned to ICT as a potential platform for delivering services and economic growth [1]. ICT has a significant impact on developed countries, in contrast to developing countries, which are struggling to adapt to the facilities by ICT. There are many factors which affect the adoption of ICT in developing countries including cultural differences and higher illiteracy rate. There are 773 million illiterate people around the world [2], mostly living in developing countries. These differences in literacy levels have a substantial impact on ICT usage.

According to UNESCO, illiteracy is defined as a person's inability to read or write short simple sentence in his daily life [3]. Whereas, semiliterate are those who have learned to write read or write a few sentences but have not carried on the learning to master their literacy skills [4]. Designing interactive UIs for rural users in the developing world has been a long-standing challenge for design researchers as stated by [5], since semiliterate users have low cognitive abilities, self – efficacy issues, visual memorization issues, and inadequate problem-solving skills [6]. Therefore, it is difficult for such users to interact with the technology. Taking into consideration limited skills of the users, the requirement of UI development for semiliterate users is different. Illiteracy is one of the significant hurdles in the effective usability of ICT solutions [7]. Therefore, researchers from Human Computer Interaction (HCI) domain are focusing on the UI design of ICT applications and interaction of users with these applications. The interaction with ICT is measured in terms of various aspects as usability and UX. According to the ISO 9241-210 [8] and ISO 9241-11 [9] standards, usability is referred to as the pragmatic aspects of the product while UX accesses the emotional aspect of interactions of users with the UI respectively. The UX of a product depends upon aesthetics and usability of a product. Therefore, enhancing the usability of a product positively effects the UX for the users [10].

Moreover, during the pandemic period of COVID-19, ICT intervention should be taken advantage of to the fullest. Several ICT based initiatives are launched in the world as a web portal to provide the updated statistical report on COVID – 19 including digital interactive maps, awareness, and prevention measures. World Health Organization (WHO) has gone into partnership with different social media platforms (e.g., Facebook, WhatsApp) to provide authentic information as well as health alert messaging service [11] [12]. Lack of adequate knowledge about the needs of users and the context

of use can result in detrimental outcomes, such as lack of acceptance of the product by the intended audience [13].

This study from the HCI domain indicates the design factors to inform and inspect design decisions that can help close the gap of developing an application and adaptation by the target user. In this regard, these factors act as design directions serving to inform the designing of the products to deliver products that are useful, usable, and providing a positive UX. However, literature is scarce regarding guidelines specific to the development of products meant for use in developing countries in the scope of HCI4D [14]. However, despite the wealth of literature in the application development for the semiliterate users, there are a lack of comprehensive research-based, state-of-the-art, systematic, HCI based UI design factors and guidelines required for the target participants. Therefore, most of the design factors for the development of UI for functionally illiterate or semiliterate are gathered from the literature. This research provides a consolidated and coherent roadmap for designers and practitioners to develop UI for semiliterate users. This study includes interface design factors to develop efficient interfaces for semiliterate users.

The main contributions of this study include: (i) an evidence-based discussion of the design factors required for the development of UI for semiliterate users, (ii) and an up-to-date map of the state-of-the-art systematic design guidelines for UI development of semiliterate users, spanning publications from 2010 to 2020. (iii) Moreover, the study discusses future research opportunities and potential trends in the UI development of semiliterate users.

2. RELATED WORK

Several ICT applications have been developed in scoping several domains, accommodating the needs of illiterate users. These applications disseminate the benefits of ICT, not just limiting to the literate community. The long history of research into development of UI for semiliterate or illiterate users show the development of applications in the domain of healthcare [15][16][17], agriculture [18][19], social networking [20],banking [21][22] financial management [23], education [24][25], e-government [26], e-commerce [27], vocational training [24], and job search[28][29][30]. A detailed study has been conducted in these domains, but a generalized findings regarding applications developed in various fields for semiliterate/illiterate user are discussed in this section. The applications of UI development cover several domains including the number of articles listed in Figure 1.

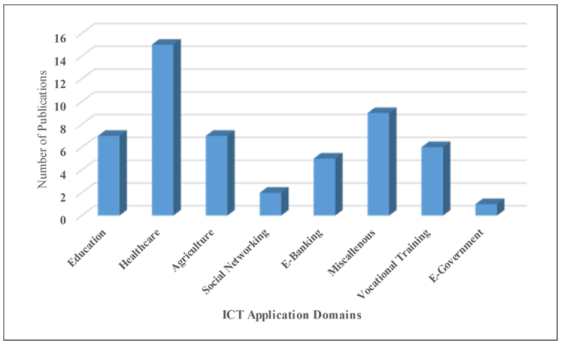

Figure 1: ICT applications in various domains developed for semiliterate and illiterate users

2.1. E-Banking

Due to an increase in the adoption of ICT in the developing countries, ICT researchers have designed applications of financial management for the semiliterate community. Moreover, they are provided with the benefit of managing financial management through mobile phones at the ease of their remote location [31]. Various applications provide E-Payment facility for illiterate users. Researchers have designed applications as simple as possible to make the adoption of financial management easy by the target community [32].

Similarly, loan payment applications are developed to facilitate the semiliterate community in their socio-economic growth [21],[23]. Besides, the financial management applications are provided with the facility to compute money bills along with the payment's module [33]. For the semiliterate users to recognize the currency notes in the interface, studies are conducted to provide financial management applications incorporating the UI development for illiterate users [33].

2.2. E-Commerce

ICT has also prevailed in the domain of online shopping. E-commerce is becoming the new norm. In such a situation, illiterate and semiliterate users should not be left behind. Therefore, researchers have developed websites and applications for online shopping of the target community. The study by [27] suggests a UI for illiterate users for online shopping of garments, clothing, and shoes.

2.3. Education

ICT4D has promoted E-Learning for the illiterate community through digital means. It includes the utilization of daily usage cellular phones for learning to count, writing through dotted lines on the interface, and scenario-based calculations learning [25]. For the phonemic awareness to educate the semiliterate users, an android application is developed to enhance the language

skills [34]. Similarly, the study [35] proposed an application, which includes learning tools that help to develop reading skills, build vocabulary, and master calculations.

To promote education for illiterate users, a collaborative platform is developed, integrating the expertise of the literate community to educate the illiterate participants. This learning platform encourages communication between readers and volunteers. The mobile application allowed a user to share a text containing an image with a volunteer translator, illiterate user can record and distribute their audio translation to the literate community, who helped the illiterate users to learn [36]. For educating the semiliterate users, virtual agents (teachers) are provided in UI to facilitate the learning process for the target participants [37].Now, the latest studies report educating the illiterate community through various chatbot applications. These chatbot applications are a gap to fill where it is tough for the population to afford quality education [38].

Vocational Training

For increasing the socio-economic condition of the developing countries, the researchers have utilized ICT in providing illiterate users with vocational training [24]. The study [39] discusses the vocational training of plumbing for the target community. These trainings are provided to users through interactive and rich multimedia content. Similarly, to check the factors required for the development of UI for the participants, they were offered different videos for vocational training like to use vacuum cleaner [40]. These applications train semiliterate workers in their daily job tasks.

2.4. Job Search

Easy access to jobs' information can play a vibrant role in getting employment. In developing countries, the target population does not have access to vital information on employment. These websites can help to enhance the socio-economic development of the country. Therefore, the researchers are contributing their part in providing job search websites for illiterate users. The study [30] developed a job search website for the illiterate users through which they can apply for the job without the help of external users. Not forgetting the importance of mobile devices, mobile job search applications are also developed and integrated. The study [41] discusses the job search application for the mobile phone users of the illiterate community. Perhaps, the existing websites provide static websites for the users, but Kalsoom et. al.[29] provides the facility of dynamic job search websites for illiterate users.

2.5. Agriculture

ICT4D researchers have designed various applications in the domain of agriculture to provide ease to the farmers in their activities. The facilities span from video content for agriculture activities to help farmers in their work [42]. Weather forecast information system for providing timely access to weather information stimulates crop productivity in rural areas [18][43]. Moreover, an application is designed for local farmers to report pest incidences and share pest-related details [19].

The ICT integration provides applications for timely access to accurate rainfall, humidity, atmospheric pressure, etc. information to illiterate farmers. This information is helpful for crop productivity. It helps the farmers to make appropriate decisions and improve agricultural outcomes [18][44]. Extending the work of information access to farmers, ICT4D has also designed conversational agents to answer the required queries of farmers [45]. Moreover, to facilitate farmers in hydroponic farming, an android application is developed. The application provides a low-cost solution to help farmers get the knowledge of farms remotely, reducing labor, and providing accurate data [7]. Farmers are not only provided UI for ease with farming activities, but for their family health, nutrition, maternity care, sanitation, etc. interfaces are also developed to offer them guidance in these domains [46]. Correspondingly, the talking book gadget provides multiple information to farmers regarding agriculture and healthcare [5].

2.6. Social Networking

Social Networking ICT4D community has also provided the facility of social networking. These applications do not only provide social interaction with the users but a fun factor along with learning regarding their posts [20]. Likewise, illiterate farmers are provided social networking application to post queries and comments on the post, regarding agriculture purposes [6]. Similarly, another application of social networking provides SMS facility providing communication facility for the users [47][48].

2.7. E- Health

In the healthcare domain, developers have worked a lot to provide facilities to the illiterate community. These facilities involve the usage of specific factors to be incorporated for UI development of semiliterate users [49][50]. ICT has been utilized in healthcare to provide a first-aid application to the target users. This application helped the users to learn first aid activities without external help. Various first—aid activities were included as hand burn, choking, head injury, feet injury [17]. Similarly, to provide facility to patients

of Tuberculosis, a low-cost device is constructed to get the benefit of ICT intervention for illiterate patients. This medical kit device helps the patient to learn about the disease and medication. This device results in supervising therapy for patients helping them during the treatment by guiding them about the disease and medication procedure [51]. Separate applications are developed for health workers of semiliterate community to interview tuberculosis patients and upload their symptoms via phone to access their six-month long treatment. UI is developed after many design iterations incorporating feedback from the target community [31]. Community health workers are facilitated with the applications of vaccine stock management systems. They help them to know the timely shortage in stock and wastage of medicines [15]. Similarly, for the semiliterate health workers in rural areas, applications are offered to support their work related to maternal healthcare [52]. This study elaborates on the use of UI providing personalized information regarding the requirement of the health workers. This concept flows from generic to personalized learning for health workers [53].

For maternal and child healthcare, applications in the healthcare domain are developed using UCD methodology. The provided facility is for mothers to learn health- related topics. ICT helps to improve healthcare access and quality for mothers and children in rural communities [54]. Similarly, an application for breastfeeding for mothers have been developed, taking into considerations of the illiterate users. It can help reduce child death rates and assist mothers for appropriate breastfeeding and growth monitoring [55].

Mobile apps for mental wellbeing offer applications for combating depression. These services are provided for people around the world who do not have access to care, but few apps are culturally targeted at this population. For combating depression among semiliterate community users, the application is developed, incorporating the needs of the target community [56]. For the semiliterate users to take benefit of m-health applications, affective computing is implemented. It makes interface fun for target users, providing the opportunity to take advantage of the ICT and reducing the digital divide [16][57].

For chronic kidney disease patients who undergo dialysis, these patients undergo a strict diet. In this scenario, not to forget the illiterate patients suffering from this disease. An application is developed to guide, help, and to learn with fun using different games devoted to guiding them about their diet [58]. Another application, digital mobile diary, is designed for the patients undergoing peritoneal dialysis. It provides information about patient health, activities, and mental states [59].

2.8. E-Government

The goal of many government agencies is to succeed in adopting and improving e- government. During this phase, user needs must be well understood. For this purpose, the developing countries have faced issues of adoption. E-Government, a web-based system is provided for the illiterate to get the benefits. This system is a prototype in Saudi Arabia. The prototype is evaluated to test usability according to the requirement of the target participant [26].

2.9. Miscellaneous

ICT4D has covered all the domains to benefit illiterate users. Therefore, researchers have also designed web browsers, especially for the target community to take its benefit. This work can be helpful for users to easily navigate internet applications, viewing content related to e-commerce, e-health, e-banking, job searching, etc. [60]. It helps to make semiliterate users independent in performing tasks during internet access. Ahmad et al. [61] provided a virtual character aid in the UI so the users do not require external help while filling forms or navigating the UIs. This virtual character can be an alternative to external help. Taking it to a level above the research community has also designed programs to convert text into pictograms, helping the illiterate users to comprehend the UI effectively [62]. Similarly, as illiterate users find it easy to navigate a text free interface with graphics. An application is implemented to convert the interfaces to cartoon graphics, making the interfaces easily comprehensible by the target participants [63].

Applications are developed for illiterate users to equip them for emergencies by sharing information through the internet regarding disaster [64]. Moreover, many mobile applications are also developed to make the UI easy to use for the illiterate community. The study [65] illustrate the factors required for the development of mobile UI for the illiterate participants by identifying the challenges and proving UI solution to the existing problems [66][67]. In the same way, for the development of mobile UI development, data is collected from illiterate users to identify solutions to issues encountered by the users [68].

3. RESEARCH METHODOLOGY

For the design guidelines of UI development of semiliterate users, a comprehensive SLR is conducted. The procedure suggested by Kitchenham and Charters [69] has been adopted, including some features of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) consortium reported in the PRISMA 2009 Checklist [70]. The process includes

planning, researching, and reporting phases. The stages are elaborated in the proceeding sections, including the formulation of research questions, selection of databases, formulation of inclusion, and exclusion criteria for the selection of relevant literature. Analysis of literature by elaborating on the design guidelines for the UI development of semiliterate users is conducted.

A preliminary review was undertaken before preparing the new SLR to ensure that no previous SLRs were carried out on design guidelines required for UI development of the semiliterate users. If this were the case, a new one would not be needed. The verification was performed by searching through the electronic databases of Google Scholar, IEEE, ACM, and Springer with the queries of ("SLR" AND "semiliterate") and the target of this SLR were searched with the queries ("Systematic literature review" AND "semiliterate" OR "User Interface"), ("UI" AND "Systematic literature review" and "semiliterate" OR "illiterate") along with other queries as ("HCI" AND "Systematic literature review" OR "UI" OR "Design guidelines" AND "semiliterate" OR "illiterate"). The results of these queries have indicated that no systematic literature reviews on the topic of discussion in this paper were conducted. Therefore, it supports the justification of conducting this SLR.

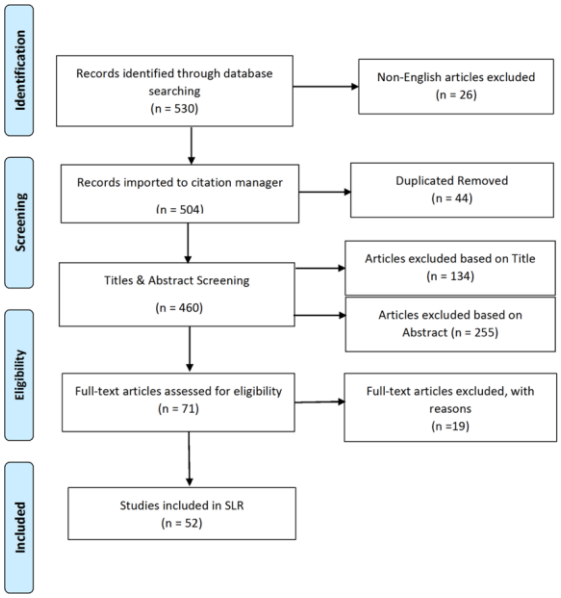

Figure 2: PRISMA 2009 flow diagram for this systematic review.

3.1. Research Questions

Investigating the gap of providing systematic guidelines for UI development of semiliterate users, the following two questions arose are:

RQ1: What are the factors required for UI development of semiliterate users?

RQ2: What are the required design guidelines for UI development of semiliterate users?

3.2. Database and Search Strategy

In line with the research methodology, step 1 involves a systematic search of the scientific literature on the topic of UI development for semiliterate users. Scopus, Google Scholar, IEEE, ACM, and Springer databases are searched for the literature. The search was conducted using the combination of logical terms 'and/or.' Key search terms included user interface AND semiliterate, user interface AND illiterate, HCI AND semiliterate OR low-literate, ICT AND semiliterate AND applications, besides another query including applications AND semiliterate, was applied as a search string. The focus was on the papers, including interface development with design considerations. Furthermore, Figure 2 establishes the PRISMA flow diagram for this systematic review to illustrate the procedure for the data collection. All the required articles after scrutiny were retrieved in full text.

3.3. Inclusion and Exclusion Criteria

The retrieved literature was evaluated by the authors based on the inclusion and exclusion criteria, as mentioned in Table 1. The initial search output contained 530 research articles published from 2010 to 2020. After organizing the studies, forty-four duplicates, and non-English twenty-six articles were removed, remaining was incorporated for the next phase of the analysis. During the next step, the exclusion criteria were followed. Some exclusion criteria were set before importing the bibliography. Initially, the abstract of papers was reviewed.

Table 1: Inclusion and Exclusion Criteria

Selection Criteria	Scientific Databases	
Inclusion	Journals, Conference papers, books etc.	
Exclusion	Prior to importation to a bibliographic manager	Non-English articles, articles with missing abstracts.
	During title screening	Generic articles related to ICT semiliterate/illiterate users including social

		science articles.
	During abstract screening	Articles related to ICT and semiliterate/illiterate users without application development.
	During full text screening	Articles not concluding design considerations for target users.

Moreover, many research articles were excluded due to non-relevancy with the topic. Therefore, three-hundred and eighty-nine articles were rejected based on abstract and title screening. Seventy-one articles were finally shortlisted for review after the full-text screening out of these fifty-two articles met the inclusion criteria of having the design factors for the semiliterate users.

The graph in Figure 3 shows that a total of fifty-two articles were selected from the electronic repositories, followed by a total of 9 (17.3%) from the Scopus database. Other electronic database repositories recorded 43 articles each: IEEE: 11 (21.2%); ACM: 24 (46.2%); Springer: 8 (15.4%).

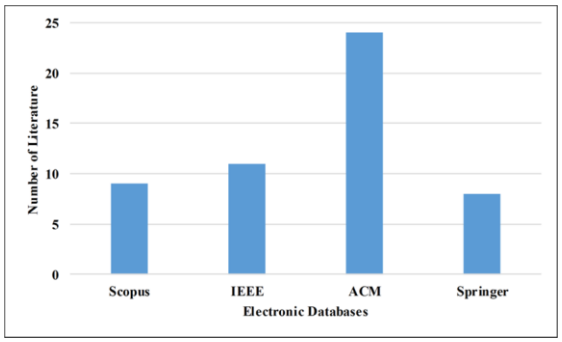

Figure 3: Articles distribution by databases.

A category-wise analysis of the selected literature is shown in Figure 4. The literature of the survey is collected from conference proceedings, journal articles and books. The graph illustrates 71% of the literature is gathered from conference proceedings, and a smaller percentage of 23% were gathered from the journals. The remaining 6% were published as books etc.

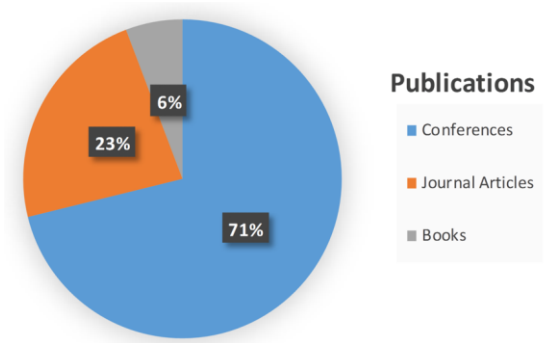

Figure 4: Analysis of selected literature per type of publication.

Many studies show the usage of different modalities and factors for developing efficient UI for semiliterate users. The studies included in SLR consists of experimental design or literature studies. The papers selected for SLR are scrutinized to drill down the details. In the chosen studies, as illustrated in Figure 5, 25% of the studies have followed the methodology of prototype development and implemented quantitative analysis to deduce the results. 36.5% of the research articles have utilized qualitative data analysis for data gathering and prototype development to incorporate the needs of the target community for the development phase. 15.3% of the studies have used mixed method approaches during the research phase. 5.7% of the articles have utilized literature to shed light on the guidelines to be required for UI development of illiterate users. The remaining 19.2% of the studies have developed a prototype but have not evaluated but concluded the design standards from the prototype designed.

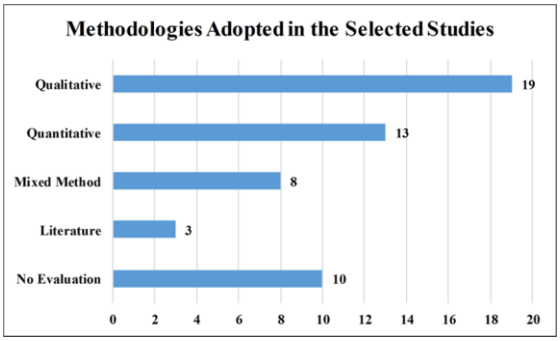

Figure 5: The methodology utilized in SLR selected paper.

4. Design Factors for UI Development of Semiliterate User

To address the RQ1 mentioned in Section 3.1, the factors utilized and analysed in UI development. The factors investigated in the studies, include the text [28][24], icons [23][25], graphics [16][22][29], graphs [49][53], animations [51][37], audio [59][46], video [68][64], arabic numerals [40], scrolling [36], navigation [32][45], localization [20][21][52], feedback [29][31], virtual characters [61][71], mental model [44][53], personalization [14][53] and consistency [34]. These factors

provide a better UX, but in what way the factors are to be incorporated for the efficient interface design? The factors are presented in Figure 6 along with the summary of the factors is shown in Table 2. This paper investigates these factors taking into consideration the needs of semiliterate users.

Figure 6: Factors required for UI development of semiliterate users.

There are many experimental design studies of developing applications for semiliterate users providing different guidelines for UI development incorporating various factors. These factors required by designers to design UI for semiliterate users are discussed. An elaboration of the factors of how to be incorporated in the UI are discussed in this Section. It presents the answer to the RQ2.

4.1. Text

Research have focused on the usage of text in many ways for UI development. Vocational training application for rural communities has utilized minimum text on the interface to be easily comprehendible by the user [24]. An e-government system developed by [26], suggests that a text free interface enhances usability for target users. An employment-based search application is designed to facilitate illiterate for finding the required job. This study presents the use of minimal text in the interface to have efficient and effective UI [28]. Similarly, a mobile-based UI for community health workers is designed by [52] suggest that the text free interface is used effectively by the semiliterate/illiterate user.

Along with the minimal use of text, research also suggest developing text-free interfaces with GUI and color schemes that attract illiterate users. For GUI, pictograms are used to represent objects. They were first used in the cave walls of Africa and Europe over 30,000 years ago. These include drawing for describing an object to be utilized for communication. When the users navigate the text in the interface, the pictures are displayed as a tooltip to help illiterate users to understand the text more easily. In an application for illiterate community the text was translated into pictograms for the illiterate population [62]. The target population appreciated the pictograms used for the interactive interface. The results showed a successful utilization of the prototype by the target population. 'EasyTexting' proposed by [48] is an SMS application using pictograms for the illiterate population. Users were comfortable using the application with audio, text, and pictogram visuals.

4.2. Icons

Icons based UI provided a usable interface for illiterate users. A mobile money application is developed. The research suggests the use of real-life money icons to lower the cognitive pressure on the illiterate user [22]. Design of a financial management application 'SalaPrayana' for the illiterate and semiliterate users used the icons for interaction with the interface. The study proved that icons were more recognizable by the target community [23]. The researchers [34] have utilized images to represent ideas that a standard interface would convey textually. The results showed increased enjoyment of interacting with the interface. 'Ustaad,' an application for teaching semiliterate users, had utilized icons to teach the population. The study revealed the users had a positive response in using the application [25]. Various research suggests the UI design guideline to use icons with labels. The icons help the user to understand the UI quickly. [59] suggested the placement of icons with labels for better understanding.

An android based job search application is developed for illiterate users of the developing country of Bangladesh, incorporating icons, helping users to comprehend the interface effectively [41]. Citizen science research was conducted using smartphone-based data collection tools with semiliterate people identified that majority of the population preferred hand-drawn icons [68]. Language independent icon-based interfaces helped the semiliterate users in retrieving the required information from the web [60].

4.3. Graphics

The study suggested that designing useful UI for illiterate users, images should be incorporated [16]. A first aid application compared the sketch-based interface and image-based interface. This empirical study proved that hand-drawn sketch-based UI were preferred by the illiterate community [17]. The paper [26] proposed to use real-life images, whether countries or environments, captivate the semiliterate users' attention. The study [50] demonstrated a graphical video representation of heart disease for a better understanding of the semiliterate and illiterate population.

For facilitating the semiliterate population, e-commerce applications are developed. The usability evaluation of this prototype suggested

researchers utilized sketches as these are more amenable for illiterate [27]. Similarly, a job search website for illiterate users suggested the use of hand-drawn graphics. The results showed that the accuracy of identification of hand-drawn images was 100% by the target population [29]. Moreover, 'Parichaya' is an application that explored in-depth use of graphics in the creation of a medical application for illiterate patients of Tuberculosis. It helped the target community to learn about the disease and the importance of their therapy [51]. The interface was accepted among users due to the graphical qualities.

"VideoKheti", an application to provide video content to the semiliterate users recommended that the participants were often not able to remember the words and therefore used touch and graphics more [42]. Through a usability study with 200 participants, the results conclude that the semiliterate user groups easily comprehend hand-drawn graphics. 'Karaoke' is an assistive technology to help illiterate users in learning using graphics and visual aids [47].

4.4. Graphs

Graphical representations are used for visual communication that is complex in the form of text. The main advantage of it is that it can convey a lot of information in graphical representation. This technique can be more interactive by the usage of icons. When icons are incorporated in graphs, they are known as "icon array." The study [49] suggests the use of icon array in graphs so that the semiliterate users easily comprehend them as the complex terms of confidence intervals and survival curves cannot be understood by the functionally illiterate. 'ASHA,' a web-based application, provided the facility of graphs for the semiliterate community health workers. The graphs were shown in the local language to be easily understood by the community [53].

4.5. Animations

The animation is an essential factor to be incorporated in UI development for semiliterate users. It helps the user to comprehend the interface and capture the attention. A study designed a mobile application for preventing depression in low income or semiliterate population utilized images for animations. Such UIs resulted in higher adoption of these applications [56]. An E-Learning system is developed to teach semiliterate users. Rahman [46] proposed that long verbal descriptions might be avoided by some graphics based animated illustrations to make it enjoyable.

4.6. Audio

Audio is considered as an integral factor for UI development of semiliterate users. Similarly, [65] suggested the use of audio feedback for semiliterate users to enhance the usability of the interface for better UX.

4.7. Video

Various studies in the literature suggest using video support for semiliterate users in interface development. A study for pre-notification of disaster using ICT for the illiterate utilizes videos for the development of UI [64].

4.8. Multimedia

UI requiring interaction with multiple senses are termed as 'Multimedia'. Researchers emphasize to utilize multimedia for UI of illiterate or semiliterate users. Different modalities (hand-drawn graphics, photographs, video, and animations) are compared in various studies. The study [15] proves the claim that illiterate users appreciated the combination of text with the icons in the UI. The paper [26] proposed an e-government system for adoption by developing country semiliterate or illiterate, suggest using audio which can be helpful in conjunction with concepts that do not have agreement representation or images. Similarly, a job search website proposed by [30], for illiterate suggested the use of graphical content with audio support. The quantitative research results showed a usable interface. An application of SMS suggests the use of icons with other modalities as audio are useful for the development of UI for semiliterate users [48].

'FarmChat'[45], a chatbot for facilitating the users compared two interfaces audio-only and audio+text. The results showed that illiterate participants struggled with audio+text interfaces but learned to use the audio only interface. Wang [35] developed 'Litebox', an educational UI for illiterate users to develop reading skills. The qualitative analysis proofs utilization of audio+text interfaces to be a better choice for UI development of illiterate users. A vocational training application for illiterate users is developed using various multimedia, a combination of audio, video, and textual interface for interaction with the user. It provided a useful UI for the training of the users and creating opportunities for jobs [39].

Similarly, a study with UCD methodology is conducted for the dissemination of healthcare information. The study claims that the healthcare topics for illiterate users should be illustrated in various formats, including video, audio, text, and images, for a better understanding of the UI [54]. The author [33] utilized multimedia with icons and audio for mobile money applications. Idrees et al. [72] recommended design guidelines to use audio along with video intervention for the target community UI development. The results conclude

that rich multimedia interfaces are better for the semiliterate population rather than the text-only interfaces.

4.9. Arabic Numerals

Various authors in the literature suggest that the semiliterate users understand arabic numerals. It spreads the idea of a "numeric interface" for the illiterate population. 'KrishiPustak' [40], an audio-visual social networking site for illiterate farmers. It incorporated the use of arabic numerals to denote the number of replies to a post.

4.10. Scrolling

Scrolling is the activity navigating the UI for moving text and graphics across the interface. It is a factor utilized in providing the usable UI development for the target subjects. 'SpeakmyText', an application that has implemented no scrolling activity for its users. It resulted in better efficiency of the UI [36]. Mehdi [47] designed UI for novice and semiliterate users. 48 out of 90 users were unable to understand the scrollbars. There it was advised to avoid the usage of scrollbars in interface design.

4.11. Navigation

Navigation plays a vital role in enhancing the usability of the interface. The study [36] proposed 'Speakmytext', an application for the conversion of text to audio had shortened the length and breadth to perform the tasks and doesn't require to scroll for completing the tasks. Such factors incorporation empirically shows an easy-to-use UI. The author [34] proposed an educational application that guided users for tasks in linear navigation design, organizing screens in sequential order. These factors provided ease of use for UI.

Surendran [32] developed an e-Payment application that provides a linear hierarchy to navigate the UI by the illiterate user easily. Therefore, the number of ways to complete the tasks should be shortened. In a study conducted by [73-75], the authors suggest users with lower cognition easily understand the use of linear navigation in UI. The paper [59] developed an application in the healthcare sector for the semiliterate users, recommend the use of linear navigation as the user performed best when navigating a linear structure. It was concluded that the linear navigation structure, shortening the length and breadth of a website, helped them to perform tasks efficiently by limiting the number of ways a user can access the tasks.

4.12. Localization

The content provided for the users should be easy for them to comprehend. An application developed for semiliterate farmers is advised to use local language to be able to take benefit of the application to the fullest [18]. A study interviewed farmers about mobile UI development. It stated to use the keypad in dual language (both in English and the local language)[20]. E-Banking research in developing country India claimed that the banking applications are not in the native language, which becomes a hurdle for the target community to utilize the applications [21].

'Chakuri Bazar' [28], suggest the use of local language for the job search website. 'Speakmytext' application supported the local language of users, which illustrated a positive effect on interaction with UI [32]. The author [52] developed a mobile-based application related to the healthcare domain, suggest the voice instructions to be in local language. The terminologies and languages used should be in the native language as users are familiar with it. It is suggested to provide content in the local language and local accent [14]. Therefore, applications should follow the factor of localization to enhance the adoption of ICT by the target community.

To reduce the digital divide, it is recommended to provide text in the local language in UI for illiterate users [41]. The study [42] explored the use of a multimodal speech interface in a novice rural population using an ASR for local language/dialects, and it recommended the usage of localization. The researcher [73] created a weather forecast information interface for farmers in Pakistan. The author proposed Urdu localized real-time mobile updates according to the user's preferences. The users responded well to the interface. Botha [68] provided a mobile interface design framework state that in developing countries, the inculcation of the local language and accent, as well as involvement of local users during the design phase, is a critical factor for design.

'ShishuPoshan' [56], an application developed for mothers to address queries related to breastfeeding. This application is designed for developing countries and utilizes the local language feature, which helps the application to be easily comprehendible by the target population. Similarly, 'The Talking Book' [54], an application developed to disseminate health and agriculture information to rural communities. This study suggests that icons should be designed but taken into consideration of localization aspects of different cultures. The study [55] proposed an application of weather forecast system for farmers suggests using local language to be more useful for illiterate farmers. The study [56] developed 'Nsmav-Bot', an educational tutoring system for the illiterate, utilizes local language for teaching the target population. The utilization of localization factors by various researchers has

made it mandatory to be used during efficient UI development.

4.13. Feedback

The semiliterate population enjoyed the feedback mechanism. Job search website for illiterate claims through the qualitative research that voice feedback reduced the hesitation of the participants to interact with the interface [25]. In designing a game for semiliterate users by [54], in an interview, the users said that they preferred feedback at every stage. The study [67] identified design problems that there is no providence of error feedback for the users. Therefore, this design factor should be leveraged during the design of applications for the desired population.

4.14. Virtual Character

Virtual characters are used in various domains. Virtual characters can be a motivation for semiliterate users and are considered as an alternative to human assistance [58]. With the usage of a virtual character, now the latest studies have incorporated the virtual assistant in UI. These virtual assistants can provide support to perform tasks while using smartphones. Researchers have extended this facility for illiterate users. The study [31] prototyped an online job application form for semiliterate users using virtual characters. The results showed that including virtual character increases the user's task completion rate and efficiency. It concludes to use virtual characters for a functionally illiterate community. 'Adheetee' [32], the facility of a virtual assistant to Banglis in their local language. Therefore, even the illiterate community can benefit from it. Furthermore, the study [59] utilized a virtual teacher for a particular school illiterate child. The prototype was successful for users with cognitive impairment.

4.15. Mental Model

The design guidelines in the literature suggest the use of the mental model in UI development. The study conducted by [39] incorporates the mental model in the banking website to take a loan. It enhanced the usability of the UI. The study [34] suggests that design plays a crucial role in the development of E-Health applications and incorporates a mental model for better design solutions.

4.16. Personalization

Personalization is vital for the development of interfaces for semiliterate users. The study [18] utilized personalization features for semiliterate community health workers. Seventy-one participants were part of the study, and the users responded to the personalized website well. Deveas [35] implemented a prototype for framers, and after the evaluation phase, it concluded that personalization features should be added to the interface for the target community.

4.17. Consistency

To reduce the cognitive load on semiliterate users, the research for educational interface provided consistency of the interface [30]. Consistency in UI resulted in ease of use for the participants. Additionally, [60] conducted a study with 140 participants to provide guidelines for web-based interfaces. It recommended using consistent language in the interface to be helpful for users

5. DISCUSSION

A heat map is to visualize the emergence and incorporation of factors for the design of UI of illiterate users during the years of 2010-2020. No data is the white spaces, less information as red, high data is color is light green, the factor having the highest information is colored as dark green illustrated in Figure 7. The map shows that within the last five years majority of work is done on most of the factors. It shows the frequency of each factor worked over the years. The white areas indicate no work is conducted about the respective factors. It opens a road for future research work of factors mental model and personalization as illustrated in Figure 7.

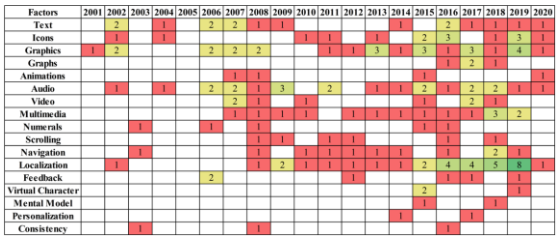

Figure 7: Heat map of factors for UI development for semiliterate users.

The literature survey illustrating the factors which are required for the development of UI for semiliterate users is shown in Figure 8. From these factors the graph in Figure 8 shows that the most widely investigated factor is localization. Thus, it is recommended for the dissemination of ICT to the target population. It should include features as text in the local language, audio, video support in local language and accent [18]. Moreover, for implementing the localization factor, different cultures should also be considered. UI should be culturally related to the culture and norms of the society [54]. The second most extensively used factor is graphics. It is highly recommended in literature by the ICT4D researchers the use of less text or text free interfaces utilizing graphics. Therefore, the literature implements various tools for text to cartoon generation and pictograms. The rest statistics in the graph illustrated in Figure 8 concludes the usage of text, icons, video, graphs, audio, video, arabic numerals, scrolling, navigation, mental model, personalization, and statistics.

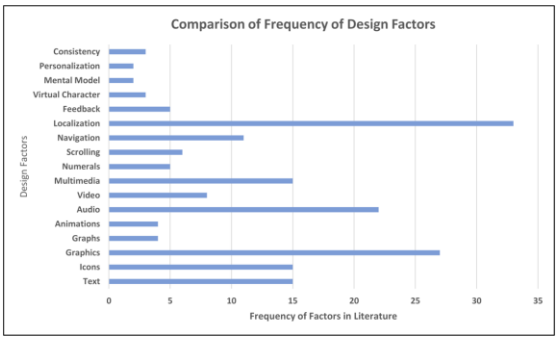

Figure 8: Analysis of factors required for the development of UI.

The taxonomies of factors for UI development along with the summary of design guidelines are shown in Table 2. Each design guideline is demonstrated with support of literature. Following these design guidelines from the HCI domain can increase the usability of UI for semiliterate users.

Table 2: Design Guidelines for Semiliterate Users

Taxonomies	Design Guidelines
Text	Minimal Use of text Text Free Pictograms
Icons	Use of Icons Icons along with caption
Graphics	Use of graphics Cartoons for pictorial content Hand-drawn representations Semi-abstract graphics
Graphs	Graphical Illustration Icon Array
Animations	Animation of visual content
Audio	Audio short and simple Audio feedback Voice annotation over mouse over
Multimedia	Text with other modalities (Compliment with audio and video support) Icons with other modalities (Compliment with text and audio support) Audio with other modalities (Compliment with text and audio support) Graphics with other modalities (Compliment with audio and visual support)
Arabic Numerals	Use of Arabic numerals
Scrolling	No Scrolling
Navigation	Linear Navigation Limit the ways to accomplish the tasks Navigation length and breadth shorter
Localization	Use of localization Text in local language Audio support in native language Audio support in native accent Culturally related UI Video in native language
Feedback	Feedback for errors
Virtual Character	Virtual character aid Virtual assistant aid
Mental Model	Use of mental model
Personalization	Customization and personalization
Consistency	Consistent look and feel in design

6. Conclusions and Future Work

To cope with the problem of illiteracy for the adoption of ICT by the target population, HCI4D researchers have provided several studies to investigate the development of UI. This paper presents an SLR to identify and analyze these latest UI development factors for the semiliterate/illiterate users. The goal of this study was to gather the state-of-the-art factors for UI development of semiliterate users which could guide further developments in this field. Moreover, this review covers design guidelines for semiliterate and illiterate users. Table 2 provides a summary of the design factors to be incorporated during UI development. The study also provides an all-in-one guideline for the designers to develop

applications for the target users. During the application development, designers can compare the usage of different factors and include in the applications according to the cognitive abilities of the semiliterate users.

These factors can be helpful during the COVID-19 time to shift to the paradigm of online. It can be beneficial for countries and save them from spreading of the COVID-19 if the maximum activities are shifted online to retain the country's economy. The efficiency of interactivity can be increased by the development of UI incorporating the design factors in a manner comprehensible by users with lower cognitive abilities. For enhancing the usability and improving UX the analysis demonstrates that localization and graphics are the most important ones to incorporate for providing ICT solutions to the target population.

In the future, this research can be extended by providing a more detailed view of design guidelines by comparison of different factors. A Multi-Criteria Decision Analysis (MCDA) technique can be implemented to prioritize the guidelines for designers. This prioritization can provide a framework for designers to be focused on the most important design factors from that mentioned in Table 2, for the effective UI development for semiliterate/illiterate users. Moreover, the heat map sheds light on the factors of personalization, mental model, and consistency for future research aspects to design effective UI for target community. Moreover, in future the factors should be categorized according to the domain in a detailed study.

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