

User-Centered Design in Developing Countries: A Case Study of a Sustainable Intercultural Healthcare Platform in Ethiopia

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Abstract—User-centered design (UCD) is a well-established development methodology that focuses during the whole design process on users' goals and context. This is especially important in software development projects in developing countries, where the development and use situations typically greatly diverge. We are currently conducting a joint research project pursuing technology-enabled maternal and child healthcare in rural areas of Ethiopia. In this paper, we report our findings and lessons learned from employing a UCD approach to address challenges stemming from lack of education, lack of training, and mostly illiterate users.

Keywords—User-centered design, developing countries, Ethiopia, case study, healthcare

I. INTRODUCTION

User-centered design (UCD) is a development methodology, first described around 30 years ago, that emphasizes usability goals, user characteristics, and context of use during all stages of the design process [6]. In [9], UCD is defined as *the active involvement of users for a clear understanding of user and task requirements, iterative design and evaluation, and a multi-disciplinary approach*. User requirements are thus central to UCD processes; the design is typically iteratively developed, evaluated, and refined through investigative methods such as usability testing, prototype testing, or field studies [9]. An analysis of existing work in this area shows a positive correlation between user participation or involvement and system success [1].

UCD is a well-established software development methodology in industrialized countries, but it is even more important in developing countries, where the gap between software development and the local use situation is larger than in western countries [2]. This gap is larger still in rural areas, where even the basic conditions expected in industrialized countries cannot be met. Developing countries, such as Ethiopia, are characterized

by big differences in education and livelihood. Lack of training, lack of experience and awareness, and lack of project management skills characterize the software development situation in Ethiopia [4][8]. Heterogeneous cultures among different ethnic groups and between rural and urban contexts are additional challenges for Ethiopian software development [3].

TEMACC, or Technology-Enabled Maternal and Child Healthcare in Ethiopia, is a research project that aims to explore the potential of information and communication technologies (ICT) to improve healthcare access and quality for mothers and children in rural communities. It is an attempt to contribute to aspects of two of the UN Sustainable Development Goals [13], namely SDG 3: Ensure healthy lives and promote well-being for all at all ages and SDG 5: Achieve gender equality and empower all women and girls. TEMACC is an interdisciplinary effort by professionals from the ICT fields together with specialists from public health and medicine.

In this paper, we report on a case study we conducted while eliciting user requirements and developing software prototypes in the TEMACC project. The software was developed at Addis Ababa University (AAU) in Ethiopia to support mothers and different stakeholders of the local health system in rural areas. We report lessons learned and findings from several field studies and workshops held to collect requirements and validate the software prototypes with end-users.

In Section 2, we present the goals and background of the TEMACC project and describe the health system in Ethiopia. Section 3 presents the research questions and methods. Section 4 illustrates the case study we conducted, and Section 5 presents our findings and lessons learned. We conclude the paper in Section 6 with an outlook for the community-based intervention study.

II. BACKGROUND

We are currently conducting a research project pursuing technology-enabled maternal and child healthcare in rural areas of Ethiopia. This is a joint research project between Addis Ababa University in Ethiopia and Johannes Kepler University (JKU) Linz, Austria. All software development work is performed locally in Addis Ababa by Ethiopians. The Austrian partner supervises and guides this development work and is responsible for project coordination.

TEMACC addresses maternal and child healthcare provision by *primary healthcare units* each comprising one *health center* and five satellite *health posts*. Ethiopia's health system is structured differently from that of the western world. At the lowest level are health extension workers (HEWs), who are the primary contact for basic health issues like vaccinations, contraception, or basic check-ups for mothers and their children. HEWs typically have one year of education after 10th grade and often originate from the villages they look after. At the next level are health centers, the personnel of which have a four-year medical education. At these locations, for example, pregnant women are supposed to give birth to their children. At the highest level are hospitals with medical doctors who have six to seven years of education.

According to the CIA World Fact Book [11] and the Internet World Stats [12], Ethiopia has a population of 108 million, more than 80% of whom live in rural areas. Forty-one percent of women and 57% of men are not able to read or write. One percent of the population uses fixed phone lines, while mobile cellular subscriptions stand at 59%, with steadily increasing numbers. Internet penetration is 15.3%.

The main stakeholders of TEMACC are *mothers* (many assumed to be illiterate), *HEWs* working at health posts (tenth grade education), and *health professionals* assigned to health centers (e.g., nurses, health officers) and local and regional *health bureaus*. The project focuses on facilitating the work and education of HEWs, the health education of mothers, and the communication between mothers and HEWs.

We focus primarily on information exchange by providing an IT-supported cooperation platform for HEWs, health professionals, health bureaus, and the local hospitals. As part of the TEMACC project, we have developed an Android app for mothers that offers basic information about pregnancy, birth, and babies, such as information on nutrition or hygiene. The app can be used by illiterate women. Information is read to them in their local language, and navigation of the content is possible without the need to read. The mothers' app additionally reminds women of antenatal and postnatal dates like preventive medical check-ups or date of delivery. For HEWs, we have developed web-based systems they can use on tablets to access health-related information for the education of mothers, as well as information to continue their own education. The web-based system also contains basic patient data that health centers can also access so that HEWs and health centers can exchange information about mothers when needed. Last but not least, the web-based system will be used as a means of communication to help less-educated medical personnel get in touch with specialists to discuss medical problems.

The TEMACC project started in 2017. In the first year, we primarily collected user requirements by conducting a multitude of field trips to rural areas in Ethiopia. In 2018, we started developing software prototypes and validating them through workshops with end-users, again in rural areas. The development of the above-described software systems was mostly finished by the end of 2018. We are currently testing these software systems. In order to assess the impact of the research project and to promote the educational aspect of the research, a community-based intervention study will be performed in 2019. We expect that the knowledge-sharing platforms and online, multimedia learning materials will demonstrate the impact of technology-assisted educational delivery in rural settings, with special emphasis on the improvement of HEWs' skills and knowledge.

Three groups are involved in the TEMACC project:

- **Project Management Group.**
The project management group is composed of representative professors from JKU and AAU, as well as well-reputed international advisors. People in the management group play the roles of sponsors, quality controllers, and technical advisors to the other project teams. The team totals seven people.
- **User Study Group.**
The user study group is composed of information systems researchers, public health researchers, and domain experts like gynecologists, representatives of direct users (rural health center staff), and software engineers. Members of this group work both directly with users (in determining requirements through field studies and ethnography) and with software engineers (in designing, testing, and deploying required software). The user study group consists of 10 people.
- **Software Development Group.**
The software development group is composed of people responsible for user interface design, quality assurance, back-end development, mobile app development, and web development. The group has a total of eight people, all of whom have university-level educations in information or computer science from AAU.

III. RESEARCH QUESTION AND METHODS

The *research goal* of the TEMACC project is to explore the potential of ICT to improve healthcare access and quality for mothers and children in rural communities.

The *research objective* is to develop an appropriate ICT-based service platform that:

- Enables mothers to receive public-health-related information without needing to travel long distances;
- Helps HEWs interact with a specialist elsewhere without leaving their hometown or locality;
- Allows collaboration and consultation among healthcare professionals, and
- Creates virtual professional communities for improving maternal and child healthcare.

The underlying *research question* is whether the maternal and child healthcare practices of rural communities can be significantly improved using information and communication technologies.

The *research methods* applied are participatory [5] and ethnographic action research [7] with the direct participation and active collaboration of the user community. Ethnographic action research is an approach particularly suited for understanding different cultures. A key method in the approach is participant observation, where the ethnographer participates in the culture or society being studied [7]. The purpose of action research is to impact social change with specific actions [5]. Participants actively contribute to the research in all phases of the process [5].

For understanding usage context, the main data collection methods were interviews and focus group discussions. Interviews and discussions were in a free, conversational style with the goal of revealing more detailed information than structured interviews would have. Also, interview questions and discussion guides were piloted before actual use. Based on the results of the pilot, we made a decision to make interviews conversationally flexible and to use audio recordings of the sessions for later analysis. Various brainstorming sessions were held with respective stakeholders regarding the communication methods employed amongst community members, usual sources of healthcare information, extent of use of technology (such as mobile phones) for communication and access to information, challenges encountered in sharing information, and existing knowledge-sharing mechanisms.

IV. CASE STUDY

Ethnographic action research and participatory design methodologies were applied to gather user requirements and evaluate software prototypes. First, we worked actively to create a common and clear understanding of ethnographic research throughout the team. We followed this with field visits to conduct interviews and focus group discussions with mothers, HEWs, and health officers. The international standards for the ergonomics of human system interaction and human-centered design for interactive systems have standardized UCD, defining it in terms of six principles and four activities [10]. The four activities are: (1) understanding and specifying the context of use, (2) specifying user requirements, (3) producing design solutions to meet user requirements, and (4) evaluating the design against the requirements.

In order to understand and specify the context of use, we first conducted interviews and focus group discussions with HEWs with the objective to discuss issues related to their sociocultural conditions, activities at their health posts, and the community outreach, infrastructure, and challenges they encounter in their daily work, as well as the level of help provided by various stakeholders. Also discussed were selected topics in maternal and child health education, major knowledge gaps on health issues in the community, and level of ICT utilization (such as smart phone usage, computer resources, and barriers). Prior to the start of the interviews, we introduced the project objectives and focus and participatory design approaches. In the process, we informed the health workers that the idea was to jointly design the envisaged technology platform with them and explained that nothing without their consent would be developed for use.

During this round of field visits, we also gave HEWs diaries to record any peculiar activities, challenges, or best practices they experienced in their day-to-day activities over a period of three weeks.

We conducted the second set of interviews with mothers, aiming to understand their existing level of awareness with respect to antenatal care (e.g., follow up, danger signs, birth preparedness, nutrition, hygiene, safe delivery), neonatal care (e.g., breast feeding, cleanliness, baby bathing, burping, balanced diet, care for sick babies), postnatal care (e.g., family planning awareness, preventing unwanted pregnancies, abortion, counseling, consultation facilities), nutrition (e.g., optimal feeding practices, growth monitoring, body building foods, disease-protecting foods), sick child services (e.g., diarrhea, malaria, pneumonia, vaccination), and hygiene (e.g., clean water usage, personal hygiene, food hygiene, toilet usage). The interviews with mothers also gave us the opportunity to observe the sociocultural and economic situation of the community. During face-to-face discussions, we made extra effort to create a friendly atmosphere prior to starting the interviews through, for example, warm cultural greetings, asking whether coffee is ready, and playing with children. We only started interviews once the team felt that mothers were ready for a friendly conversation, and we attempted to build emotional trust and openness.

All interviews and focus group discussions were conducted in Amharic with a semi-structured interview guide. Since the interviews were more conversational in style, a digital audio recorder was used to record the discussions. In each interview session, the team worked in pairs (one member from public health and one from software development, paying particular attention to gender: at least one member of each team was female). One team member moderated the interview, and the other took notes. Audio recordings were later transcribed and translated into English. We also created meta-data and summaries of the interviews and focus group discussions in order to support the specification of user requirements.

The identified usage context also helped us to learn about the availability and access to information on maternal and child healthcare. The issues identified were prioritized and used as the basis for design solutions, including health content, based on paper mockups and mobile application prototypes. The paper mockups, prototypes, and initial content were used as additional instruments to gather more user requirements. In preparing to develop the prototypes, the content development team was tasked to compile relevant content based on healthcare materials made available by the Ethiopian Ministry of Health (MoH). The initial version of the health content was developed with reference to national maternal- and child health-related guidelines. The major topics covered were antenatal care, postnatal care, vaccination, nutrition, hygiene, and baby sickness. We also attempted to align content with user stories that we had already collected and identified during the preliminary investigation. In total, over 100 digitized content slides were prepared for use in the mobile prototype application. The content was prepared in both text and audio formats.

To evaluate the design against the requirements, we gathered feedback from the use of both the paper prototypes and the mobile prototype applications in several sessions with prospective

users: mothers, HEWs, and health experts. In these sessions, groups of five to 10 users used the system and provided feedback to members of our user study group. We used this feedback in early stages to revise requirements. In later stages, we gave this feedback to the software development group in order to enhance or change specific aspects. For example, we use icons for the user interface on the mobile phones for mothers. Mothers misunderstood or simply found unacceptable some of the icons. For example, an icon showing a sick baby in a bed was not accepted, because in rural areas of Ethiopia, children do not sleep in beds. Another example is an icon of a child washing hands under a faucet. Again, this situation is not common in rural areas. Mothers misunderstood the icon as a child playing with bubbles.

Evaluation has shown that proper design increased the chance that mothers would be interested in using these applications. According to the observations we made, most were eager to actively try the prototypes and provide feedback, despite their indifference and relatively limited participation during the earlier preliminary investigation. We assume that the fact that they were able to have a hands-on experience contributed to their active participation. It was also surprising to learn that even those mothers who claimed to be illiterate had no difficulty identifying numbers from 1 up to 10.

An example requirement is that mothers should have an application on their mobile phones that contains basic maternal and child health care information. They should be able to listen to the available information in their own language, supported by video. Fig. 1 shows the user interface of the mothers' app, which contains icons that mothers can use to get information on specific content areas such as antenatal care, nutrition, hygiene, and sickness. Navigation information is shown using images in order to allow illiterate users to easily navigate. Content itself is shown in the local language and read out loud, again to allow illiterate users to understand the information. Fig. 3 shows members of the user study group instructing mothers in the use of the TEMACC app on their phones.

Another requirement from a different group of users was that information about pregnant women should be recordable. Fig. 2 shows a dialog for HEWs to enter that information. The HEW system is web-based and can be used on personal computers or on tablets. The use of tablets is important, because HEWs visit mothers and pregnant women in their villages and need to be able to access relevant information while on the move.

V. LESSONS LEARNED

We now present the lessons learned from the described field studies with respect to the software development context, the usage context, and the content of the software systems.

A. Software Development Context

From our experiences in the TEMACC project so far, the main challenges with respect to software development in developing countries are:

- Scarcity of human resources in rural areas, particularly regarding ICT experts;
- Poorly educated software developers and service or maintenance personnel in rural areas;



Fig. 1. Mothers' App

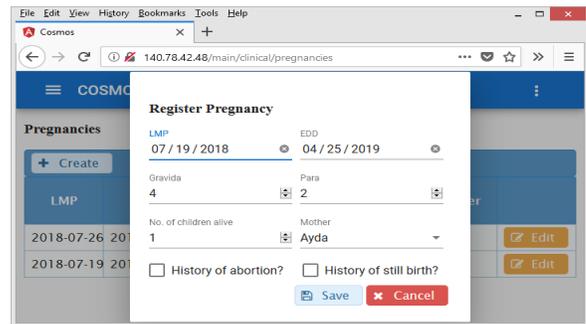


Fig. 2. HEW System



Fig. 3. Members of the User Study Group Instructing Mothers

- Poor infrastructure in terms of electric power reliability and network availability; and
- Lack of established organizational structures, especially in rural areas.

B. Usage Context

The main challenges with respect to users and the usage context of software systems in developing rural areas are:

- Low education level of user groups (e.g., mothers poorly understand educational materials, healthcare personnel cannot speak English);
- Many illiterate users (e.g., mothers cannot read or write or put their signatures on documents);
- Users have little or no experience with ICT and need training on the basic operation of computers (e.g., users have difficulty operating tablets and lack awareness that information published on the Internet may not be reliable); and
- Cultural and gender issues (e.g., mothers feel uncomfortable taking advice from a younger person or from a woman who does not have children, mothers in general do not trust healthcare personnel, mothers are not allowed to use their husband's mobile phone).

C. Health-Related Content

The main challenges with respect to the content of the software systems in developing rural areas are:

- Content selection, (e.g., health content can be selected only from approved material by the Ethiopian MoH);
- Content organization and structure (e.g., mothers were often observed to simply click on numbers without first listening to the content, so content needs to be separated into small, easy-to-understand chunks); and
- Cultural issues related to content (e.g., mothers did not immediately identify an image of a baby getting vaccinated as such).

VI. CONCLUSION AND FUTURE WORK

We are conducting a research project to explore the potential of ICT to improve healthcare access and quality for mothers and children in rural communities. So far, we have elicited user requirements and developed a set of software systems for mothers, HEWs, and health professionals. UCD was, it turned out, an absolute necessity to identify users' needs. Compared to a developed-world context, we had to deal with many unfamiliar challenges related to software development, usage, and content, including illiterate users, poor connectivity, and challenges related to content structure.

We are currently conducting a community-based intervention study until the end of 2019 to assess the impact of the research project and to promote the educational aspect of the research. The study is being performed in a selected district within 100 to 200 km of Addis Ababa. After conducting a baseline survey, the target groups will be provided with tablets and mobile phones and given appropriate training to access vital information on various health-related topics in various formats including video, audio, text, and images. Arrangements will also

be made for health professionals working in the health centers of these districts to use the web-based systems and the knowledge-exchange platforms to support virtual consultation and referral services at the expert and professional levels. The third district will serve as a control group with no technology intervention. After nine months of intervention, an end-line survey will be conducted to examine the effect of the intervention and to make comparisons. The adoption of the technology solution will also be reflected upon in terms of increasing awareness and evaluating the extent to which the community demonstrated an interest in the innovation as compared to other available options.

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