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DESIGNING AND TESTING A MOBILE APP TO FIGHT CHILD, EARLY, AND FORCED MARRIAGE IN DEVELOPING COUNTRIES

Research paper

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Abstract

Child marriage is still a severe issue in developing countries. Among the strategies that work most to fight it, is empowering girls with information combined with the education of parents and community. As smartphones are more accessible year after year in developing countries, we want to investigate how a mobile app could effectively fight child marriage and which characteristics such an app should have. The research was organized into three main phases. The first phase was focused on 4 expert semi-structured interviews to understand if an app could be a good solution to help in fighting child marriage. The second and third phases were based on a case study with young girls in the Democratic Republic of the Congo. The second phase had focus groups with 26 girls to test and improve the requisites of the app, and the third phase had a questionnaire that 14 girls had to fill out after trying the app. The study shows that girls in developing countries have access to smartphones, and most can use the developed app satisfactorily and that it is worth continuing to study this problem as an app could be a new instrument to use alongside traditional tools.

Keywords: Child Marriage, Mobile App, ICT4D, Low-Literate Users, Digital Illiterate Users, Developing Countries.

1 Introduction

Among the UN's Sustainable Development Goals (SDGs), number 5.3 aims to "Eliminate all harmful practices, such as child, early, and forced marriage and female genital mutilation" by 2030 (United Nations, 2015). However, there are only seven years left until the deadline, and although data show a decrease of 15% in the number of children married each year, 100 million girls are predicted to marry before the age of 18 by 2030, and the COVID-19 pandemic has put additional 10 million girls at risk (UNICEF, 2021a). Child marriage is a marriage that involves people under 18 years of age; forced marriage is a marriage in which at least one party does not express their free and full consent (United Nations, 2021); early marriage refers to unions where at least a party is under the age of 18, but it is considered an adult according to the laws or norms of the country in which they live (Plan International Asia-Pacific Regional Hub, 2021). Child, early, and forced marriage is considered a human rights violation primarily affecting girls (United Nations, 2021). This practice is diffused worldwide, but the higher percentages are found in less developed countries, where 36% of women aged 20-24 were married before 18 and 10% before 15 (UNICEF, 2021b).

Several factors lead to child marriage and vary from place to place (Kohno *et al.*, 2020). The most common are insecurity and conflicts, legal issues, family values, religion, individual beliefs and knowledge, and social norms (Kohno *et al.*, 2020). Moreover, child marriage is complicated to treat as conditional preferences sustain it (Bicchieri, Jiang and Lindemans, 2014). In the last two decades, many interventions have been actuated to fight child marriage, both from private and public organizations. The strategies of the different programs have been classified by the International Center for Research on Women (ICRW) (Lee-Rife *et al.*, 2012) into five main categories based on their approach: 1) Empowering girls with information, skills, and support networks; 2) Educating and mobilizing parents and community members; 3) Enhancing the accessibility and quality of formal schooling for girls; 4) Offering economic support and incentives for girls and their families; and 5) Fostering an enabling legal and policy framework. The analysis made by ICRW (Lee-Rife *et al.*, 2012) and Psaki *et al.* (2021) evidenced that among the interventions that seem to work more, there is the empowerment of girls with information combined with the education of parents and communities. In a recent study, Malhontra and Elnakib (2021) found that the most effective way to fight child marriage is to provide families with money to support girls' education. However, it is not possible to implement such a method in a widespread setting as too many funds would be necessary. Moreover, according to this study, only 3 out of 11 studies focused on girls' empowerment showed positive results. Nevertheless, none of them used a mobile app, and only one preliminary study (Brevik, Jaccheri and Vidal, 2019) has been published in the academic literature on this topic, showing that there is a need for research. As Non-Governmental Organizations' (NGOs) reports show that projects that used digital technologies had a positive outcome (Plan International Asia-Pacific Regional Hub, 2021), we deem this approach worth to be studied.

Technology and mobile phones are accessible by an increasing number of people in developing countries (GSMA, 2022), and some research in the field of Information and Communication Technologies for Development (ICT4D) studies the usage of mobile applications (or apps) with various purposes in developing countries. Previous research (Leong, Tan and Ahuja, 2020; Dietz, Hund and Wagner, 2022; Wilson and Patón-Romero, 2022) shows that target 5.3 of the UN's 2030 agenda is rarely or never addressed by the Information Systems community and IT projects, probably because the behaviors are well established in the culture and challenging to fight with software. However, Plan International's report on digital technologies used to combat child marriage (Plan International Asia-Pacific Regional Hub, 2021) describes various mobile apps used to fight child marriage locally with a positive outcome. Inspired by one of these apps, Brevik (2019) designed a mobile app to combat child marriage globally, proposing and testing six designs. Given the increase in the usage of mobile phones and smartphones, we decided to investigate how a mobile app to empower girls and families with information could be a helpful tool to use next to the traditional interventions to fight child marriage. We focused on a version of the app that targets girls. And with this end, we formulated the first research question as follows: *How can a mobile app targeting girls in developing countries help in the fight against child marriage?* As this does not come without challenges and opportunities, we formulated the second research question as follows: *What opportunities and challenges can be identified in connection with an app to fight child marriage in developing countries?*

We applied design science (Hevner and Chatterjee, 2010) and case study (Yin, 2017) methodologies to address our research questions. First, we started from the designs proposed by Brevik *et al.* (2019) and added more functionalities and features based on the literature from Information and Communication Technologies for Development (ICT4D). Successively, we conducted 4 expert interviews with people from different countries and analyzed them with thematic analysis, obtaining a refined list of guidelines that brought to the design of a prototype. Then, we run a case study with 26 girls in the Democratic Republic of the Congo (DRC) to understand how girls in developing countries perceive child marriage and an app to fight it and to gain feedback on the prototype through focus groups. Afterward, we implemented and tested the app's first version in the same setting with a session where 14 girls from the DRC tried the app and filled in an evaluation questionnaire. The main contribution of this research is the development of an app usable by girls in the DRC but adaptable to many different realities as it is built in a modular way. Moreover, most of the research about gender equality and IT

(Patón-Romero *et al.*, 2022; Wilson and Patón-Romero, 2022) focuses on how digital technologies works against gender equality, while we propose a solution that uses digital technologies to increase gender equality.

The outline of the paper is as follows: Section 2 analyzes the literature related to the research topic; Section 3 covers the research methods and the research process; Sections 4, 5, and 6 explain the different phases of the research focusing respectively on expert interviews, prototype testing, and app testing; Section 7 discusses the results and limitations; and Section 8 closes the paper with a summary of the project and future works.

2 Background

ICT4D research regarding mobile technologies is mostly focused on IVR (Interactive Voice Response) and SMS (Short Message Service) communication technologies, as the majority of devices owned by people in developing countries is not a smartphone (GSMA, 2022). However, these technologies allow only text messages and voice calls, creating many limitations to the artifacts that cannot offer many functionalities (Kapinga, Montero and Mbise, 2019). Mobile apps are defined as “software that runs on a mobile device and perform certain tasks for the user” (Islam and Mazumder, 2010); they can offer more services than plain IVR and SMS, as they are not limited to communications, work without connection, and are free. A mobile app has the advantages of being offline and portable, offering many different user experiences in the same place and tailoring the content to the person using it. Finally, it can offer emergency support with contacts to relevant people and organizations as long as different learning experiences, from reading plain text to serious games. Moreover, smartphones’ diffusion and usage are expected to grow in the near future due to the fast advance in technology that contributes to decreasing the costs of devices and services (Kapinga, Montero and Mbise, 2019; GSMA, 2022). Studies of ICT4D that regard mobile apps are still not a lot and most focus on finding design guidelines for technology-illiterate people. Only a few of the researchers try to estimate the impact and usability of mobile apps, and they show that people in developing countries can successfully use apps; some examples could be: a mobile banking app in Kenya (Mbiti and Weil, 2011), a gamified app for education in Sri Lanka (Halloluwa *et al.*, 2017), and an entrepreneurship development app for women in Tanzania (Kapinga, Montero and Mbise, 2019). Numerous obstacles arise due to variables such as poor internet connection quality and high costs, as well as potential users’ low level of education and digital illiteracy. In 2018, Brevik *et al.* proposed six different designs for an app to fight child marriage (Brevik, 2019; Brevik, Jaccheri and Vidal, 2019) and tested them in Malawi with village leaders and adolescent girls. All the participants in the study affirmed that a mobile app is a good way to try to fight child marriage (Brevik, 2019). The interfaces proposed in the study are: 1) Informational: gives general information about themes such as education, laws, health problems, common questions, and agriculture. It also has an emergency call functionality; 2) Argumentative: aims to disrupt the false superstitions and beliefs around child marriage and reproductive health and to explain the danger of such practices to parents; 3) Story-Based: contains personal success stories of young girls to motivate the users; 4) Video: shows local videos with transcription; 5) Contact: provides contacts of local people and organizations; 6) Links: collects useful links to NGOs’ (Non-Governmental Organizations) publications to deepen users’ knowledge about the topics related to child marriage. Previous work (Brevik, Jaccheri and Vidal, 2019) underestimated some factors derived from the developing countries setting. First of all, the literacy level of youth females in low-developed countries is assessed to be around 77% according to the UNESCO Institute for Statistics (UNESCO, 2021), with some countries with a much lower percentage. As child marriage is mostly diffused in low-developed countries (UNICEF, 2021b), it is necessary to develop an app that is also usable by low-literate people. On the other hand, people may not be used to mobile apps as shown in “The mobile economy” GSMA report (GSMA, 2022), and they can manifest a fear of breaking the device because they do not know what happens when pressing a button (Medhi *et al.*, 2011). Furthermore, Srivastava *et al.* (2021) conducted an extensive systematic literature review of design guidelines

for apps that target low-literate and digitally illiterate people and developed the SARAL framework with 13 guidelines to follow when designing for this target. Another thing to take into consideration is that sharing devices is common among people in developing countries (Medhi *et al.*, 2011), which creates the requirements of keeping the user's privacy and making the app usable by more people on the same device. Finally, it is essential to follow the Principles for Digital Development when designing a mobile app that targets developing countries (Principles for Digital Development, 2017). The design and implementation of software to improve health for women and girls in low and medium-developed countries could bring many benefits, such as improved children's health, reduction of maternal and child mortality, and social and economic empowerment (GSMA, 2017). Nevertheless, reaching women in developing countries is complex and presents many challenges (GSMA, 2017).. The only reports found that express some guidelines for designing and testing software for women are two reports from UNICEF (2020a, 2020b) and a report from GSMA (2017). The development of applications targeting girls and women in developing countries is relatively recent, with few examples. An example of an app that respects the design guidelines is Oky (UNICEF), an app developed by UNICEF to help girls aged from 10 to 19 in tracking their period and giving them information about menstrual hygiene. The development of Oky followed the principles of user-centered design and a gamified approach. It is lightweight, does not require an internet connection, different users can log in on the same phone, protecting the data with a password, and is localized. Other examples of an app to fight child marriage and give information about Sexual and Reproductive Health (SHRH) developed by NGOs are Reprodutiva (Plan International), Bandhan Tod (Gender Alliance, 2018), Girl Power (Accenture, 2016), Stop Violence (APDEL, 2020), and Freedom Mobile App (Freedom Charity).

3 Methodology

This research used design science and case study as research methodologies. We employed design science (Hevner and Chatterjee, 2010) as the primary research methodology, which we applied with multiple iterations. We chose this method as it allowed us to build and refine the IT artifact, a mobile app to fight child marriage, throughout multiple iterations. We also used a case study (Yin, 2017) to run a real-world evaluation of the app without the simplifications that other methods, such as experiments and survey, have. We used interviews, focus groups, and questionnaires as the data generation methods. In the initial and central part of the research, we employed semi-structured interviews and focus groups that lead to an agreed answer through a discussion among participants (Maguire and Bevan, 2002). We encouraged dialogue with the participants to obtain more insights on the different questions and discuss unplanned topics. Finally, we used a questionnaire to evaluate the produced artifact in the last user testing session. The questionnaire contained both close and open questions. The close questions utilized mainly the Likert scale (rate from "Strongly disagree" to "Strongly agree") and semantic differential scale (for example, rate from "too difficult" to "too easy").

Data Analysis: We used qualitative and quantitative data analysis methods to analyze the collected data and performed triangulation among the data collected in the different phases of the research. For the textual data collected through interviews and focus groups, we used thematic analysis, a qualitative method, because of the nature of the data itself. We performed the coding manually with a semantic and inductive approach and used NVivo as software support. We employed simple methods and statistics, such as tables and charts, to carry out the quantitative analysis. Moreover, we performed the System Usability Scale (SUS) for the app testing, which is a reliable tool to measure the usability of a system (Lewis, 2018). The SUS is a 10 items questionnaire with sentences to be rated with a Likert scale. All the blanks were replaced with a 3 as suggested in (Lewis, 2018). Finally, we calculated the correlation between some of the data collected through the Spearman Correlation, as Likert and semantic differential scales can be considered ordinal scales.

3.1 Research Process

We structured the research process in 3 main phases: 1) **Expert Interviews**: In this phase, we proposed some improvements to the designs we found in the literature and then interviewed experts to understand if an app could be a good solution to help in fighting child marriage and what they thought about the interfaces and improvements. The analysis of the collected data brought to the design of a prototype for the app; 2) **Prototype Testing**: In this phase, we chose the Democratic Republic of Congo, where child marriage is diffused, to run a pilot study for the app. We studied the situation in the country and held focus groups with young girls to understand the needs of the target audience and have feedback on the developed prototype; 3) **App Development**: In the last phase, we built the app's first version and held another meeting to see if the girls could use the app. This time they had to fill in a questionnaire. The results brought to the development of an improved version of the app.

3.2 Participants

The participants involved in the study are shown in Table 1. In the expert interviews phase, we interviewed 4 experts from different countries, while the other two involved only girls from Eastern DRC. The girls were recruited by a local Congolese non-profit organization supporting women and girls. In the prototype testing phase, we interviewed a total of 26 girls, 21 from the urban area (Goma) and 5 from the rural area (Nyiragongo), through three Sessions. In the app testing phase, only 14 girls from Goma participated. All the interviews and meetings were performed online. We found some of the same challenges of Baez and Casati (2018) in working with vulnerable populations. We had few possibilities of meeting the target population, and finding participants in developing countries took much work. In addition, we had to deal with the ethical approval process from the Norwegian Center for Research Data (NSD), and the impossibility to go in the DRC increased the difficulties of the interactions as they had to be performed online.

As we understand the participants are vulnerable girls and the theme is delicate, gaining the ethical approval from NSD was fundamental for us. We obtained this by providing extensive documentation of all the data collected in the different phases and granting the anonymity of all participants. We wanted to be sure that the girls would not be harmed by participating in this research, and the partner organization that recruited the girls offered us this kind of assurance. They are used to talking with girls about these topics and know which language to use to communicate with them. Moreover, they are a registered and trustworthy organization that cooperates with other international NGOs.

Phase	Participants	Location	Additional info
Expert Interviews	4	Norway (2), DRC (1), South-East Asia (1)	
Prototype Testing	26	DRC: Goma (21), Nyiragongo (5)	S1 (12), S2 (8), S3 (6)
App Testing	14	DRC: Goma (14)	

Table 1. Participants in the three phases of the study. Prototype testing was run in three sessions (S1, S2, S3)

4 Expert Interviews

We started from the designs defined by (Brevik, Jaccheri and Vidal, 2019), and we established some improvements for the app based on the background literature from ICT4D that we reported in Section II. After that, we interviewed experts asking what they thought about the designs and the improvements as long as general questions on an app to fight child marriage. The designs were shown on a power point, 3 for each slide, and explained by the researcher one by one. After explaining the 3 designs in the slide, we asked the interviewee to comment on them based on their experience. Afterward, the list of improvements was presented, and feedback was asked.

4.1 Proposed Improvements

Based on the background, we propose the following improvements: 1) An audio feedback that explains what the user can do on each page; 2) A customized literacy level to set how much text needs to be read out loud; 3) A help button in every interface to help the users if they are stuck; 4) A tutorial on the first page of the app that explains what the app is about and how it works; 5) Localization in terms of language and content; 6) Registration and login to keep the privacy and allow more users on the same phone with different preferences. Other proposed improvements, not based on the literature, are: 1) The usage of quizzes and games to make the learning more engaging; 2) Showing different content to girls and parents tailored to their needs.

4.2 Expert Interviews

We interviewed 4 experts, two of them (P1 and P2) in a group interview and the others individually. P1 and P2 are employees in Norway of a worldwide NGO; P1 works on children's participation and right to express themselves, while P2 works on gender equality and sexual and reproductive health and rights. P1 and P2 answered together to all the questions so we will refer to their answers as "P1-2". P3, based in South-East Asia, is a gender and technology specialist and works for UNICEF on Oky. P4, based in the DRC, is the chairman of the board of a Congolese NGO in the water consumption sector and has previously worked as a humanitarian and journalist.

Usage of Mobile Phones in Developing Countries: Regarding the usage of technology and mobile phones, all the interviewees agreed on the presence of a gender digital divide in developing countries, with broad differences from place to place. P3 said: *"I think the gender gap in terms of mobile access is closing. Not so much in smartphone ownership and access, but where we're seeing a bigger gap is in use."* P4 also argued that in his country, women have more access to telephones in urban areas, especially young girls, while in the countryside is less common, and if they have a device, it is not a smartphone. P4 also pointed out: *"If people do not want to touch different apps (from calls and SMS) on their telephones, it is because they do not know exactly what is going to happen."* P3 and P4 also affirmed that the progress in smartphone ownership in the last years has been huge, thanks to the advance in technology and the possibility of buying used devices at a minimal price. Both P3 and P4 confirmed that in south-east Asia and Congo is very common for women and girls to share devices.

Target for the App: All the experts said that the target for this kind of app should be chosen based on the digital divide and the usage of technology in the deployment place. P1-2, for example, thought that it could be a good idea to have facilitators, such as volunteers or teachers, who could use and show the app during meetings with girls or parents in those places where fewer people have access to smartphones to reach more people. P3 argued to study how girls have access to smartphones and design for how they use technology. Finally, P4 said that the app should target girls directly, and the best usage scenario would be with two girls of almost the same age, and one of them acts as a facilitator in case the other one cannot use the phone by herself. Moreover, as child marriage impacts the whole community, it is also essential to involve parents and community workers to reach a greater audience apart from the girls.

Interface Designs: We showed all six designs to the experts, asking for their feedback. Regarding the informational design, P1-2 agreed that giving information about the presented themes is essential. P4 argued that the emergency call function is crucial if a girl risk being abused. On the argumentative design, P1-2 said that it could be helpful for teachers or health workers but not for girls, P3 did not think it could be practical, and P4 said it could work when a girl has a question but does not want to show up. All the interviewees approved the story-based design, and all reported that girls usually like story-based content and that it is easier to discuss about other people and users can learn from the actions of others in the same situation. Videos received very similar feedback, but P3 added: *"We know that users say they want videos, but the moment we add videos, we are taking away the kind of core principles which are lightweight and offline"*. About contacts, all interviewees agreed that it is essen-

tial because girls often want to talk to someone, P3 suggested putting only contacts of organizations, not singular people, and P4 claimed that in the DRC, people would not use phone calls because of the high cost of airtime. At the same time, the address of a place would be more effective. Finally, all the experts rejected the Links design as they affirmed it is not interesting for girls or parents. As a result, the following decisions over the interfaces have been made: keep Informational, Story-Based, and Contacts; delete Argumentative and Links and further evaluate the Video design based on the local use of technology.

Proposed Improvements: The proposed improvements had, in general, positive feedback. P3 and P4 gave detailed answers on every improvement, while P1-2 generally suggested: *“Look very closely at how people use technology and use that. Is it low (usage)? Why would you then use technology? I mean, because it can be in personalized, because...? And then boost that part because people are not used to using technology. Maybe that is a good thing. Maybe we could use that as a sensational event. If they are used to using technology, then you could look into functionalities and passwords and etc.”* Audio feedback has been said by both P3 and P4 to be a great idea to involve people with low levels of literacy and digital illiteracy and reduce the fear of technology. Regarding the customized literacy level, P3 reported that audio content is efficacious for low-literate people. P4 reported that the help button might be effective for those who are afraid of technology, as well as the tutorial if it does not contain a very long message. However, these two improvements need to be combined with the audio feedback. All the interviewees also agreed that localization is significant in terms of content and language. In addition, they believed that content personalization is a good improvement because parents and girls need the information to be tailored in different ways, even if they reported that parents would want to know what their children would read on the app. So, all these improvements that allow digital and low-literate users to use the app and increase its relevance are considered necessary. P3 and P4 also explained that having a login procedure is necessary to keep users’ privacy if they share the phone, and at the same time, it allows more people to use the same app with different preferences. P3 and P4 agreed that quizzes and games are an excellent way to engage the users in learning and motivating them, but it is necessary to understand if the users can use them.

Other Comments: P3 suggested that it is also necessary to use user-centered design to meet the user’s needs and their ability to use mobile phones. Furthermore, the app should fit old phones, various screen sizes and operating systems, and work offline.

5 Prototype Testing

We designed a prototype based on the expert interviews’ findings. The prototype has a welcome page with the tutorial and a home page that contains all the resources: we created four main sections, three of them recalling Informational, Story-Based, and Contact designs, and one new section with the games. Each page has a help button and audio feedback. We have developed two versions, one with login and one without it. In this first version of the app, it was decided to target only girls, and the feature of content personalization has yet to be included. To test the designed prototype, we ran three focus groups with 26 girls from the DRC. To tailor the prototype to the chosen country, we conducted a short preliminary study about DRC to investigate the situation of women and girls and technology usage. After that, the interviews focused mainly on getting to know the target group, showing the prototype, and asking for feedback.

5.1 The Democratic Republic of the Congo

The DRC is the second largest country in Africa and is in central Africa. The country has seen an exacerbating civil war that caused the diffusion of gender-based violence as well as food insecurity, displacement, and poverty (European Commission), and this situation has also incremented the school dropout (Girls Not Brides). According to the Congolese Constitution, women have the right to marry whomever they want, but the law demands a dowry payment from the groom’s to the bride’s family (OECD Development centre, 2019). Violence against women is widespread, and in conflict areas, it is

even more exacerbated as sexual violence is used as a weapon of war, and there are beliefs according to which having sex with a virgin can protect from death or bring wealth (Carlsen, 2009). Moreover, it is challenging for women to find decent work positions (UN Women Africa), and there are significant differences in salary derived from the stereotype that women should not work (UN Women Africa). School attendance is very different between boys and girls, with much more boys attending school than girls. Only the 19% of boys aged 15-19 are out of school compared to the 40% of girls (United Nations Population Fund). The legal age to get married in DRC is 18, without exceptions. Nevertheless, 37.3% of girls currently aged 20-24 were married before the age of 18 (26.8% in urban areas and 44.3% in rural areas), and 10% before the age of 15 (6% in urban areas and 12.7% in rural areas) and the 26.7% had a child while underage (United Nations Population Fund). The most significant drivers of child marriage in DRC are poverty, traditional attitudes, level of education, adolescent pregnancy, armed conflict, and displacement (Mpilambo et al., 2017; Girls Not Brides). Mobile phones are the most diffused technology in DRC, with 46.9% of the population that has a mobile phone and 37.5% of that is an internet user (Kemp, 2022). The usage of both mobile phones and internet is increasing, with an annual growth of respectively 8.9% and 25.4% between 2021 and 2022 (Kemp, 2022). We could not find official data about the usage of mobile phones by women. However, the expert interviewee P4, that lives in the DRC, affirmed that mobile phone ownership by women is consistently increasing in the last years, as reported in Section IV.

5.2 Focus Groups

We ran three sessions of 2 hours with a total of 26 girls aged 15-19. We had 12 girls for Session 1 (S1), 8 girls for session 2 (S2), and 6 girls for session 3 (S3). The girls from S1 and S2 were from Goma, while those from S3 were from a rural area called Nyiragongo. Each meeting was carried out online and organized into two parts: general questions to understand the background of the girls and a prototype explanation where we explained each screen and asked questions about the features. The focus groups were planned to last two hours, with one hour allocated to each phase. As the girls could not speak English, all the material, including the prototype, was translated into French. One of the workers from the Congolese NGO was available to participate as a translator and local expert as she works daily in helping girls and women. The facilitator received the translation of the questions in French beforehand.

General Questions: The participants were between 15 and 19 years old, and most girls attended school. When asked what a marriage is, most of them answered “*an engagement/union between two people of different sex*” and only one girl mentioned “love”. Then, despite most girls being under 18, many said they would marry as soon as they found someone. This shows that even if they are not forced to marry by their parents, they would still marry underage, and this can put them at significant risk in case of childbirth and make them abandon school. Furthermore, most of the interviewee said they did not have any place to get information about marriage and sexual and reproductive health, and the app could help them by providing that kind of information. Regarding mobile phone ownership, we found that most of the girls living in the urban area have a personal mobile phone: 10 girls out of 22 have a smartphone, while 3 do not have a personal phone. On the other hand, only 2 of the girls from rural areas have a phone, and it is not a smartphone, but all the girls said they have people at home with phones that they can use, and they reported using the internet to access Facebook. The number of girls with a smartphone overcame expectations, which shows that the technology penetration is growing in the country. The girls that have phones said they use them mainly to communicate with family and friends, both with phone calls and messages. Some reported using it for Facebook, school research and homework, downloading and watching videos, getting information about politics and what is going on in the country, finding the meaning of some new words, online courses, taking pictures, and listening to music.

Prototype Questions: We showed the prototype to the girls and explained the app’s parts. During the process, we asked different questions to see if they liked the prototype and would have been able to use it. We discovered that some girls could not speak French, which led to the necessity to prioritize

multi-language support to translate the app in Swahili. Based on the collected data and the observations, we made the following decisions about the app: 1) keep tutorial, audio feedback, and help button as the majority of the girls considered them essential; 2) prioritize the multilanguage support as some of the girls are not able to speak French; 3) have both written stories with audio and videos as some girls said they would prefer videos but others were concerned about the internet connection; 4) keep the games; 5) add a section to report a case of child marriage and one where girls can anonymously ask questions and get answers as they proposed; 6) include an SHRH content because they do not have a place to find this kind of information; and 7) keep the version without login.

Limitations: The meetings were held online, so it was not easy to interact with the girls as they only had one computer in the room. In addition, they did not speak English, so the translator always had to mediate. Accessing this target group is complex; even if we wanted more interviews with smaller groups, this was not possible. In fact, the local organization that participated in the study was not available to have more meetings as it is small and has many more urgent concerns. Moreover, the participants often answered the questions as a group after a small discussion. As a result, only the final answer was reported, and sometimes it was impossible to know who answered what. Finally, some girls could not fully understand and speak French, and the organization that recruited the participants did not know this. Consequently, the facilitator, who was also able to speak Swahili, had to translate the questions into Swahili during the meeting for them.

6 App Development and Testing

As some of the users were not used to technology, we developed an initial simplified version of the app to understand if it was usable by the users and if they liked it.

6.1 App Development

Some screenshots of the app are visible in Fig. 1. For the development of the first version of the app, some of the features were prioritized, while others were left for future development. It would not have made sense to spend much time developing the whole app to find that it was too difficult for girls in developing countries. As they had already seen the Figma prototype in the previous phase, we wanted them to try a real app to see if they could perform practical tasks on it. As the girls were not so used to smartphones, we believed that they could not have had the same experience by using Figma or another simulator compared to a real app. We are not sure that they could have imagined how the app worked by looking only at the screenshots and say if they would be able to perform the tasks. The mobile app is built in a modular way, and it is not content-specific. This means that the same code can be used to develop an app for a different place choosing which sections to include, and more modules can be developed and easily included in the project. The multi-language support allows a high number of languages without any effort apart from the plain translation. A very similar mechanism could permit the showing of different content based on the localization. Finally, we tried to make an artifact as compliant as possible with the Principles for Digital Development (Principles for Digital Development, 2017).

6.2 App Testing

We ran a second part of the case study in the DRC to test the developed app and see how the girls perceived it. The participants were 14 girls aged 15-19 from Goma, recruited by the same organization as the previous phase. Of them, 6 previously participated in the prototype testing, while the others were new to the project. During the session, the girls had to fill in a questionnaire divided into 3 parts: 1) Preliminary questions about their usage of mobile phones and related to how they get information on topics such as marriage, pregnancy, sex, etc.; 2) 3 tasks to perform on the app and answer some questions after each task; and 3) SUS and questions about the functionalities and the style of the app. The questionnaire was translated into French and printed, and all the girls filled it in on paper. They only

had one mobile phone available to use for the testing, so all the girls tried the app on the same phone. After the testing, all the answers were copied on an excel sheet and analyzed.

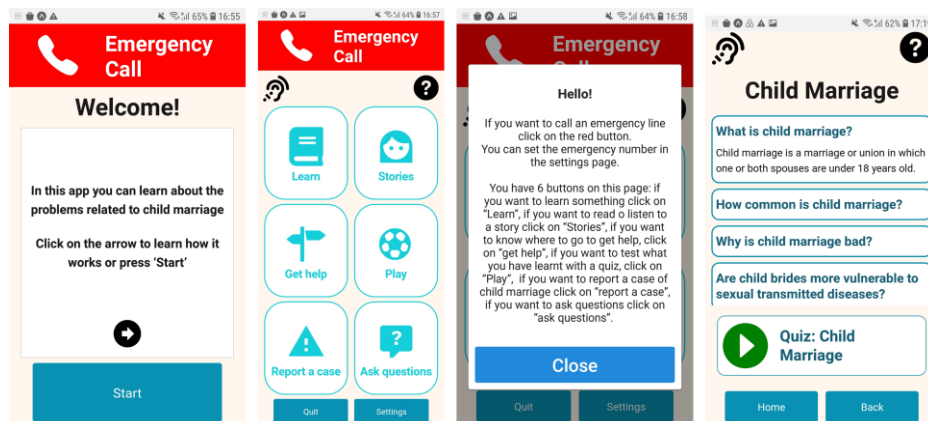


Figure 1. Screenshots of four different screens of the app. Welcome screen, Home screen, Help button screen and Learn screen

6.3 Results

Most of the girls were between 15 and 17 years old, with only two girls older than 17, and all of them were from urban areas. Regarding access to mobile phones, 43% of the participants had access to a smartphone, 14% only to an older phone, and 43% did not have access to any phone. All the girls that have smartphones use various apps on their phones, and apart from Whatsapp and Facebook, some of them reported also using Snapchat, TikTok, and Instagram. Those who only had access to an older phone reported also using Facebook, camera, and Internet research, which probably means that they did not sufficiently understand the question about the access. The same applies to those girls who answered that they did not have access to a mobile phone but then marked that they use phone calls, SMS, and internet research. As the app mainly wants to empower girls with information, we wanted to investigate how they could get information on topics such as laws, menstruation, sexual health, sex and contraception, and pregnancy. Most participants never looked at any of those topics on the internet, even if they had access to smartphones with an internet connection. The participants reported that the person with whom they can mostly speak about these topics is their mother. However, few of them can speak with her about sex and sexual health. Moreover, the quality of their information should be further examined to tailor the app's content to cover the gaps they have and correct the wrong information.

In the second part of the questionnaire, the participants had to try the app on the phone to perform 3 tasks and then answer questions about the single tasks. The tasks are: 1) *Read the tutorial, change the emergency number and call the new number* (Welcome screen, Home screen, Settings screen); 2) *Find the phone number of the organization in the app and read a story with questions about the content* (Contact screen, Stories screen) ; 3) *Read the information about child marriage in the learning session and do the quiz* (Learn screen, Games screen) Task number 1, was the most difficult for the girls, which may mean that the information given in the tutorial and the help button was not detailed enough. The girls reported using the help button in task 1 and less in the other tasks. However, they said that the information was always clear and easy to understand and that the feature was handy. In general, Settings, Get help, and Stories Screens were easy to understand according to the answers, but the Contact page should be further investigated. The participants did quite well in task 3, and most of them think they can improve their quiz scores by rereading the learning section. According to the data, the quiz questions were easy to understand, and the text in the learning section was clear for most of the girls. In addition, most participants thought quizzes and stories were valuable learning methods.

The SUS score of all 14 participants is shown in Fig. 2, and the total score of the SUS, calculated as the average of the score of the single SUS, is 63,39. This score is between *OK* (50,9) and *Good* (71,4) according to (Bangor, Kortum and Miller, 2009), meaning that the base is good, but there are things to improve to make the system more usable. The results from the SUS are deemed satisfactory as this was the first version of the app, and many participants were not used to mobile phones.

The correlation analysis results are shown in Fig. 2. The phone ownership does not seem to be correlated to how easily the participants found the various tasks ((AVG; phone), $R_s=0,07$), but there is a moderate positive correlation with the SUS score ((SUS; phone); $R_s=0,61$; $p=0,05$), and also SUS and help button have a positive correlation ((SUS; help); $R_s=0,68$; $p=0,01$). This means that girls who have access to a smartphone daily found the app more usable. Moreover, the participants who found the help button useful got a higher score in the SUS, showing that the help button increases usability. The fact that the users with a mobile phone have a higher score can indicate that the accessibility features for digital-illiterate users should be enhanced. For example, the full implementation of the audio feedback should be prioritized in the future steps of development, as well as an improvement of the text in both the tutorial and the help button. Furthermore, data shows no correlation between how easily they found the various tasks and their participation in the previous meeting ((meet; AVG); $R_s=0,02$), meaning that a previous experience with the app did not influence their user experience. Moreover, girls' participation in the prototype testing does not strongly correlate with the SUS score ((meet; SUS); $R_s=-0,23$).

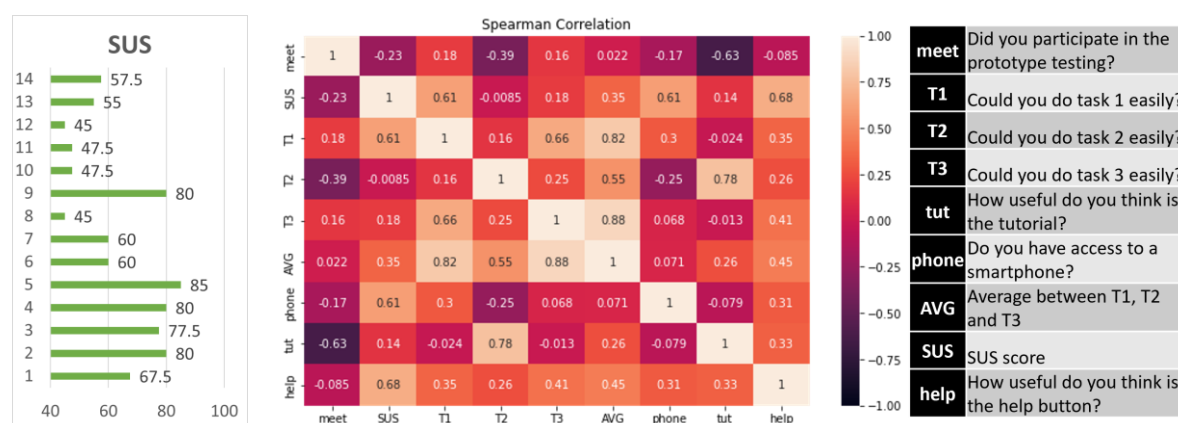


Figure 2. System Usability Scale (SUS) and Spearman Correlation Results

Limitations: The testing session was organized online as it was impossible to go to the DRC. Because of this, our testing supervision was limited and left to the facilitator, who was not an expert in technologies and this kind of testing. The facilitator reported that the participants found some questions difficult to understand because of difficult words and because it was the first time they provided feedback on mobile app, so an easier version of the questionnaire should be produced for future testing sessions. Moreover, it was not possible to have girls from the rural area in this phase as they were mostly not speaking French, and it was not possible to translate the app and the questionnaire into Swahili during the short time we had between the development and this first testing phase, so we decided to proceed with only girls from Goma. The mobile app's effectiveness has yet to be tested because part of the content still needs to be added and because of time constraints. To count a girl as a girl that escaped child marriage, ages are needed, as she must turn 18 and still not be married. So, before running this kind of test, it is worth developing a version of the app for parents and community workers to simultaneously reach the broader audience possible.

7 Discussion

This project shows that many people in developing countries own smartphones, so an app can be an additional tool to fight child marriage on the side of the traditional ones. This instrument cannot be

used everywhere and by everyone, as there are still many places where access to smartphones is limited. Nevertheless, even if only a single girl is saved from child marriage by this app, it should already be considered a success. For example, many of the girls we interviewed reported that they would marry as soon as they found a suitable husband even if their parents did not force them: they did not know what risks can be caused by early pregnancy, and an app like this could help them to learn about these topics and delay the marriage. We showed that the developed app is usable by girls from the DRC, as most of them could efficiently complete most of the proposed tasks, and we consider the SUS score satisfactory, given that many girls were not used to smartphones. Even if not all the girls have a smartphone, those who have one can use the app to learn about the topics and share the information with their friends. None of the instruments used to fight child marriage is meant to be global, so it is not a significant drawback that this is not. Moreover, after the development of the versions of the app for parents and community workers, a broader audience will be reached. We are still lacking the testing with girls from the rural area, however, child marriage is still a lot diffused in the urban areas as well, as explained in Section 5, so the app could be helpful even if only the girl from the urban area were able to use it. It was impossible to test if the app helps prevent child marriage as years are needed for this testing. However, this testing is worth being carried out after the study and development of complementary platforms for parents and social workers. Based on our first research question, a mobile app to fight child marriage can be designed as a learning app to inform people. In this way, it is designed as a combination of the interventions “empowering girls with information” and “education of parents and communities” (Psaki *et al.*, 2021). Even if the study (Malhotra and Elnakib, 2021) found that these kinds of interventions generally have a low possibility of success, none of the studies included in their review use a mobile app, and at the same time, NGOs reports and Brevik (2019), the only ones who have started researching on this topic, show positive results with this approach.

To increase the possibilities of being effective, it is necessary to target the biggest audience possible: girls, parents, and community workers. Each category needs different information tailored to their needs. Furthermore, the mobile app needs to be localized, which means it should address the drivers of child marriage in the specific region, have localized content, such as laws and stories, and be in the local language. Moreover, as the percentages of low-literate and digital-illiterate people are high in developing countries, accessibility features to allow those kinds of people to use it should be included (Srivastava *et al.*, 2021). In addition, the app should fit old phones and be partially or totally offline, and the design process should follow a user-centered design methodology and the Principles for Digital Development (Principles for Digital Development, 2017) as much as possible. If the target of the app is girls, the app should have not only child marriage specific content but also SHRH content, as it is difficult for girls in developing countries to receive correct information about these topics. Moreover, other topics and strategies such as gamification should be also considered, as they can also act as a way to incentivize the download of the app. Furthermore, it is vital to run preliminary research about the context in which the app will be deployed and have meetings with the girls throughout the development process following a user-centered design methodology. Finally, all the testing should be done with girls from developing countries. It is not meaningful to test the app in non-developing countries as the girls would be much more used to smartphones and apps.

The development of this kind of app can lift ethical concerns about giving instruments to deprived girls to raise their voices without proper support. The content of the app is to be developed by experts used to working with girls on these topics. They know the appropriate content, how to communicate it, and can explain how to behave to avoid risks. Moreover, the app should always be deployed with the collaboration of a local organization working to help women and girls who can answer the users’ questions and help them in case of necessity. Solutions to avoid risks for girls should be further investigated. One possibility would be having a controlled deployment through a trustworthy NGO. People who get in contact with these organizations would already be exposed to the topics that are addressed in the app with more traditional methods, such as meetings and discussions. The app would then act as an innovative and attractive instrument to learn about sensitive topics. In the first place, the organization should show the app on their own devices using it as a supportive tool during their activities. Only if it is appropriate and based on the knowledge they have about each personal situation, allow the

girls to install it on their personal devices. Moreover, the fact of using an app, that is an extremely innovative (and a bit mysterious) technology in this context, could potentially attract more people to the organization thanks to word of mouth among young girls. In addition, other stratagems like hiding the app's purpose in the icon and name can be explored. Potential security vulnerability in the app should also be examined before deploying it in developing countries as they pose a major risk for vulnerable girls if exploited.

To answer our second research question, an app to fight child marriage generates many challenges and opportunities. The challenges we found are reaching the recipients, be sure that this instrument is going to help and not to harm them, elaborate the right content and design something that at the same time is easy to and appealing. The opportunities that it offers are to use an innovative tool to attract more and more people, and to have an additional tool to fight child marriage. As this problem is so spread, and traditional interventions have shown their limits, this potential new tool should not be wasted.

Concerning internal validity, the sample that participated in the study is small and should be extended in future research on the topic, and the language barrier and necessity of online testing were not optimal for conducting the research. Regarding external validity, we argue that the findings from expert interviews may be generalizable but additional interviews should be carried out to validate the data. The findings from the testing in the DRC can only be generalized with further testing in other areas, and some are likely to be valid only in the DRC. This research shows that trying to pursue SDG5 with digital technologies is promising and more research is needed on this topic, as Leong et al. (2020) showed that SDG5 is rarely addressed in IS research.

8 Conclusion

In this study, we addressed the design of a mobile app to fight child marriage in developing countries. To this end, we followed the design science method with multiple iterations and performed a case study to improve and test the developed artifact. We started from the background related to child marriage and ICT4D, and the first version of design guidelines was proposed based on it. Next, the guidelines were tested with 4 expert interviews. After that, a prototype for an app that targets girls was proposed based on the results. Successively, a case study in the DRC was run through a partnership with a local organization that recruited girls aged 15-19. The user-centered development process included two sessions with girls from the DRC. It resulted in the development of the app's first version, which seemed usable by the girls. The technology is diffused enough to allow the girls to use the app, at least in urban areas, where half of the girls reported having a personal smartphone. However, after including all the missing content, more feedback should be collected, and the app should be improved following the user-centered design method. Moreover, complementary platforms for community workers and parents should be developed. The one for community workers is essential as it pairs with the one for the girls to answer their questions and deal with the case reports. Finally, the app's effectiveness should be tested, for example, using action research methods, with one group exposed to the app and another not to see if the child marriage trend diminishes. However, as already explained, this kind of testing takes years.

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Authors' note

Access to the app code and prototype can be provided under request.

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