M2M: UNIVERSALLY DESIGNED MULTIMEDIA TRAINING AND LEARNING APPLICATION FOR MATERNAL HEALTH

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ABSTRACT

The figure of Maternal Mortality Ratio in the global south is worrying and requires a serious attention from all stakeholders. Despite the progress made on maternity healthcare in the last two decades, a huge effort is still required to achieve the SDG3 target. The effort includes capacitating the health professionals and local doulas through training and learning application platforms. Universally designed multimedia training and learning applications plays such a significant role in facilitating this effort. To design an accessible maternity training and learning application, the accessibility barriers of the target diverse user groups must be identified, and the impact of the barriers need to be quantified.

In this research work, we have developed a prototype called M2M that comprises VR-based animation to identify the possible accessibility barriers of multimedia-based maternity training and learning application experienced by people with low vision through the combination of heuristic and barrier walkthrough methods.

We studied the severity of the identified accessibility barriers and their impact which will serve as a benchmark to develop a fully-fledged maternity health training and learning application for the global south. We have shown the strong correlation between the number of UI elements and the prevalence of accessibility barriers that must be considered in designing the UI/UX of the fully-fledged maternity training and learning application. We have also observed that multimedia contents must be evaluated independently for any accessibility issues before integrating the contents to training applications.

KEYWORDS

Universal Design, Universal Design for Learning, Multimedia Training and Learning Application, Maternity Training and Learning Applications, Virtual Reality-based Learning.

1. INTRODUCTION

Pregnancy and childbirth are among the beautiful phenomena that happen to humans. Maternity Healthcare aims to keep the happening of this phenomenon without any maternal mortality. This makes maternity health one of the major priorities of the SDG3 [1]. By 2030, the SDG3 targeted that the global maternity mortality ratio shall be reduced to less than 70 per 100,000 live births [1]. The creation of improved services and products through innovation is key to achieve this target. Researches have shown that innovative ICT artifacts play a significant role in achieving the SDGs especially in "*fragile, low-resource, and remote settings*" [2]. Several types of research

have revealed that multimedia e-learning platforms can facilitate the training of midwives and doulas in such an efficient and effective manner [2-6].

Some figures have shown worrying facts about maternal mortality ratios in the global south. As per the world health statistics by WHO, "*In 2016, maternal mortality was the second leading cause of death for women of reproductive age, after HIV/AIDS, and was the leading cause among women aged 15–29 years*" [7]. In 2016, about 95% of the maternal mortalities are recorded in low-income and lower-middle-income countries [7]. Africa recorded about 65% of maternal mortality in 2016 [7]. In the same year, "*1 woman in 41 who lives in low-income countries died from maternal causes*" [7]. This is generally because of poor maternity healthcare setting that is also affecting the socio-economic perspective of the Sub-Saharan African countries.

Even though most of the maternal mortalities are avoidable, they are still the headache of developing countries including Sub-Saharan African countries. The major causes of maternal mortalities are postpartum hemorrhage, hypertensive disorders, unsafe abortion, and delivery-related complications [8]. The extent of the mortality is depending on timely and adequate clinical intervention on the causes [8-10]. However, a lack of maternity health professionals including midwives is affecting the expected clinical interventions. The local doulas who often replace the role of professional midwives do not have the required knowledge and skill to tackle issues which may happen during pregnancy, at the time of delivery, and in the postpartum period [8]. Digital training facilities by remote midwives and other health professionals can improve the competencies of midwives and local doulas [11, 12].

This research attempts to address the following questions:

- How critical and culturally sensitive maternity issues are represented using accessible multimedia?
- What are the key accessibility barriers experienced by people with low vision when they interact with maternity training and learning applications?
- How can the impact of identified accessibility barriers be quantified?

The rest of the sections are organized as follows. Section two focuses on literature review. Section three deals with prototyping. Evaluation of the prototype is covered in section four. Conclusion and future works are articulated in the final section.

2. LITERATURE REVIEW

2.1. Health Communication and Key Issues

2.1.1. Health Communication

Human is a communicative and learning being. This makes communication decisive in every socio-economic activity of human life. The provision of equitable and accessible healthcare services requires effective communication. The effectiveness of health communication is measured by its positive outcome to community health [13, 14]. The primary purpose of health communication is to impact people to make timely decisions either for prevention or risk minimization [15]. Health communication is a complex process that conveys a health-related message and usually takes place in an interpersonal setting between multiple parties [13, 14].

2.1.2. Critical Factors in Health Communication

In general, the success of health communication is measured by its outcome on the involving parties. Several studies suggested different factors that decide the success of a health communication platform. In the context of this research work, the following key factors are selected since they are decisive in maternity health training applications[13, 15, 16].

- Audience-centered: The communication platform must consider individuals or groups who are communicating. Without a clear understanding of the users of the communication facility, it is difficult to deliver the intended outcome.
- Research-based: Health communication does not hit its primary purpose without a scientific articulation of the communication environment. This requires studying the "*policies*", "*social norms*", and "*key issues*" available in the environment for desired behavioral change [13].
- Cost-Effective: The communication facility has to be designed to effectively utilize "*budget and personnel*" without compromising the primary target [13].
- Strategic: The message, the channel, the communicating parties, and other relevant components must be identified and brought together in an action plan to achieve the target.
- Cultural Competency: The communication platform must cope-up with the norms and values of the target audiences.
- Adaptable: The communication facility must be adjustable to the context of the communication environment to deal with different limitations and constraints.

2.2. Maternal Healthcare Services

2.2.1. Maternal Healthcare in Sub-Saharan Africa

The sub-Saharan African region is struggling with different public health issues. Despite the effort of the region along with international humanitarian organizations including the UN and WHO, the region is still far away from achieving SDG3 targets. Maternity health problems and their consequences are among the major public health issues that the Sub-Sahara African countries are struggling to reduce. In 2015, the MMR of sub-Saharan Africa is 546 per 100,000 live births which is extremely far from the average MMR of developed countries which is 12 maternal deaths per 100,000 live births [17, 18]. In the same year, the Sub-Sahara African countries accounted for 66.3% of the global MMR which was the largest proportion in the world [19].

Some African countries like South Africa have been recording huge progress in reducing MMR. However, most of the sub-Saharan African countries are still struggling to make a significant progress in maternity healthcare. According to a study in 2013, Ethiopia MMR was 497 maternal deaths per 100,000 live births[20]. As per the study on 6299 Nigerian women who gave birth from 2007 to 2012, 34.9% of them did not attend maternal healthcare services [21]. In 2012, Mozambique MMR was also recorded high which was 500 maternal death per 100.000 live births [10]. In DRC, the MMR was very high in 2008 which was 670 per 100,000 [22]. These all figures have shown promising signs of progress from 2008 to 2018. However, DRC has remained as the sixth-highest MMR in the world in 2018 [23].

Several pieces of research studied the critical factors behind these shocking figures. "*Affordability, availability and accessibility*" were the critical factors in Nigeria and shared by other sub-Saharan African countries [10, 20, 21]. Different kinds of local and cross-national conflicts are among the critical factors for such high MMR in DRC [24]. Cultural beliefs also a

decisive factor in deciding to attend the available maternal healthcare services [25, 26]. Almost all of the above studies which are investigated the reason behind high MMR in sub-Saharan African countries mentioned a lack of skilled midwives and other health professionals as one of the critical factors.

The traditional birth attendants and doulas play a significant role in the sub-Saharan African maternity healthcare services as they are the one who combats with poor healthcare settings. In DRC, by 2008, more than 40% of births were attended by these traditional attendants or doulas [22]. In Malawi, doulas are the common options for most rural maternity health issues [27]. In 2011, more than half of births in the rural areas of Mozambique were attended by doulas [28].
The process of "*professionalization*" of these doulas is helpful to reduce MMR in sub-Saharan African countries [29]. Innovative ICTs are ideal solutions in accelerating this "*professionalization*" process by capacitating doula's knowledge and competencies through training and learning platforms [11].

2.3. Multimedia Training and Learning Platforms

Multiple media known as multimedia became the core components of e-learning platforms. This is because multimedia accelerates understanding to learners through active engagement in the learning-teaching process [4]. This is called the "*multimedia effect*" that is resulted from embedded multimedia contents in learning platforms [4]. The use of multimedia in learning platforms has several advantages including personalized education, flexibility, and comfortability for a variety of personality types [30]. Multimedia provides learners "*more control*" on the schedule, content, learning styles, and pace of education or communication [31].

2.3.1. VR-based Training and Learning Platforms

VR technologies have been applied in different sectors because of their advantage in simulating real-world scenarios. Desktop VRs are non-immersive VR environments that are widely applicable in educational landscapes to improve content browsing and hands-on experience as well as to increase learning outcome [32-34].

3. PROTOTYPING

3.1. Overview

We have designed an interactive mid-fidelity prototype called M2M using Axure RP 9 Team Edition. The M2M prototype will be used to test how users will interact with the system and to observe the accessibility barriers occurred in the interaction.

3.2. Sample Multimedia Content for the Prototype

We have prepared a sample VR-based multimedia content for the prototype using professional Autodesk® 3ds Max® 2017 and Adobe Premier Pro 2019. The VR-based multimedia content is about handling a postpartum hemorrhage which is one of the leading obstetric causes for maternal mortality in Sub-Saharan African countries[35]. We have presented a sample snapshot of the VR-based multimedia content in Figure 1.

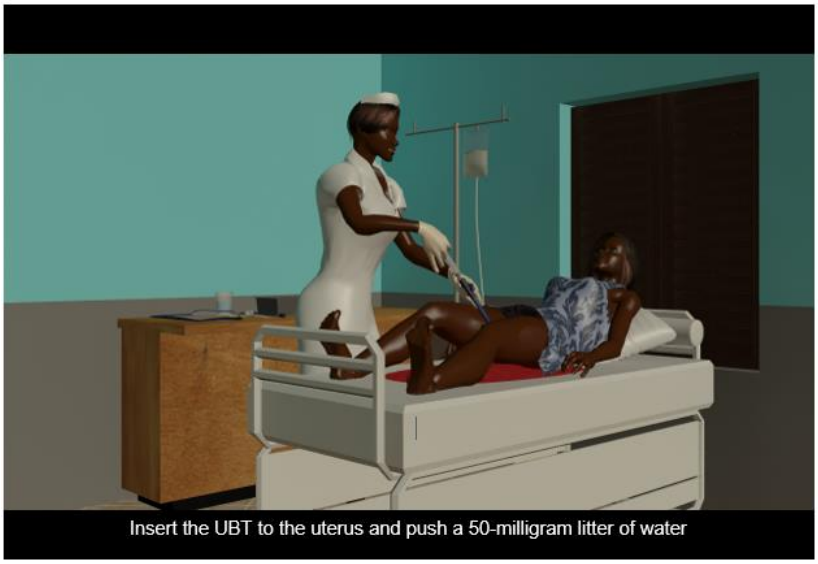

Figure 1. Snapshot of VR-based animation showing midwife inserting the uterine balloon tamponade (UBT) Kit to the Uterus

3.3. Prototype Development

3.3.1. User Flows

We have prepared user flows based on the selected functional requirements. User flows are crucial to "*determine the scope of the prototype*" and later to test accessibility and usability of the product [36, 37].

3.3.2. Building the Prototype

After all the user flows are defined, the prototype is built using Axure RP 9 Team Edition as a web application as it is depicted in Figure 2.

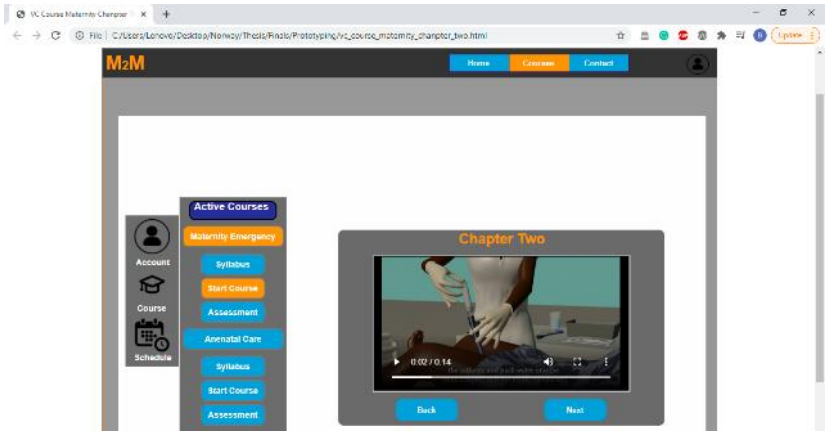

Figure 2. User is accessing Maternity Emergency course comprises VR-based animation

4. PROTOTYPE EVALUATION

4.1. Overview

We have used the heuristic web accessibility method with the combination of the barrier walkthrough and the cooperative evaluation technique to evaluate the prototype [38-40].

Firstly, we have selected three use cases of the M2M, and we have prepared three task scenarios based on the selected use cases. The selected task scenarios are 'User Registration', 'Access a Virtual Classroom', and 'Access a Maternity Emergency Course' that contains VR-based animation about Post-partum Hemorrhage. Secondly, we have defined user personas, difference in ability, and selected assistive technologies. As a result, we have identified midwives as user groups and screen magnifier as an assistive technology. We selected people with visual impairment as group of people with different abilities. Finally, we have selected interaction with mouse, touchpad, and Keyboard as interaction devices with M2M after we defined the common accessibility barriers based on the selected diverse user groups, task scenarios and selected interaction devices.

4.2. Selected Diverse User Group and Task Scenario

We have selected five participating users with low vision whose age is between 30-41 from the Sub-Saharan African region. The selected users often access web using magnifying glasses and Windows Screen Magnifier. The participated users are trained and instructed to perform the tasks stated in Table 1.

Table 1. List of Task Scenarios

Task ID	Task Description
Task1	register to M2M system by accessing the homepage.
Task2	login to M2M
Task3	access the virtual classroom
Task4	access 'Maternity Emergency' course comprises VR-based animation content from the virtual classroom.
Task5	logout from M2M.

4.3. Evaluation Setup

The evaluation takes place using the same laptop for all participants with Google Chrome Version 90.0.4430.72 in silent room where there is only one participant and one author (expert observer). The author provided a task sheet for the participants in hard copy for reference in the middle of the tasks. The tasks take 30 minutes which is 50% longer than the total task time as per the cooperative evaluation guideline [40]. The author communicated and observed the participants in the evaluation period regarding any difficulty they encounter. After the participants completed the tasks, they have responded for post-evaluation questionnaire.

4.4. Evaluation Metrics

As per the accessibility walkthrough method, the severity of a barrier is determined by the impact of the barrier on performance parameters called productivity and user satisfaction [41]. We have modified (contextualized to the M2M prototype) the suggested metrics and presented the definition of the metrics below.

- Persistence: The frequency of the barriers appeared. A total persistence is calculated as persistence multiplied by the number of users who reported that barrier.
- Severity: The degree of the effect of the barrier on the execution of a task. This value is given by the author and if it is 1-2 that means it is a minor severity and does not affect the execution of the task. If severity is between 3-5, the barrier affects task execution, but the user overcomes it using different alternatives. If the severity is greater than 5, it critically affects the task execution and user often exit the application or unable to reach task's goal.

4.5. Evaluation of the Multimedia Content

The content of the sample course is represented using VR-based animation. We didn't evaluate the mutlimeida content indepndently for any accessibility issue before integrating it to the prototype. Instead, we have included open subtitle as an access service after we complete the rendering of the anmiation.

5. RESULT AND ANALYSIS

5.1. Evaluation Result

Table 2 summarizes the evaluation result of registration task whereas Table 3summarizes the result of logging task. Table 4 summarizes the evaluation of accessing the virtual classroom and Table 5 summarizes the evaluation of accessing a course content that comprises the VR-based animation.

Table 2. Task1 Evaluation Result

Accessibility Barrier	**Total Persistence**	**Severity**	**Pages Involved**	**No of Users Reported**
Low contrast	6	Critical	homepage, registration page	3
Insufficient time to complete a task	1	Significant	user registration page	1
UI elements cannot be controlled by keyboard	7	Critical	homepage, registration page	1
No keyboard shortcut	5	Critical	homepage, registration page	1

One participant took more than ten minutes to register to M2M and could not be successful and later decided to exit the evaluation after the first task.

Table 3. Task2 Evaluation Result

Accessibility Barrier	**Total Persistence**	**Severity**	**Pages**	**No of Users Reported**
Low contrast	3	Critical	Login	3
UI elements that cannot be controlled by keyboard	1	Minor	Login	1

Table 4. Task3 Evaluation Result

Accessibility Barrier	**Total Persistence**	**Severity**	**Pages Involved**	**No of Users Reported**
Low contrast	6	Critical	VC Home, VC Course List	3
Too many UI elements	9	Critical	VC Home, VC Course List	3
Missing tooltips	3	Minor	VC Home	1
Inaccessible graphical link images	4	Significant	VC Home, VC Course List	2
less intuitive UI components	9	Critical	VC Home	3

Table 5. Task3 Evaluation Result

Accessibility Barrier	**Total Persistence**	**Severity**	**Pages Involved**	**No of Users Reported**
Low contrast	3	Critical	VC Course Maternity Chapter One	3
Missing tooltips	2	Minor	VC Course Maternity Chapter One	1
Inaccessible graphical link images	2	Minor	VC Course Maternity Chapter One	2
Non-synchronized caption	2	Minor	VC Course Maternity Chapter One	1
Non-descriptive transcript	1	Minor	VC Course Maternity Chapter One	1
No-Audio Control	4	Significant	VC Course Maternity Chapter One	4
No Audio Alert	4	Significant	VC Course Maternity Chapter One	4

There is no barrier registered for Task5 since it only requires a single-click operation to logout.

5.2. Analysis of Result

5.2.1. Severity of Tasks

The severities of the tasks are analyzed and presented in Figure 3.

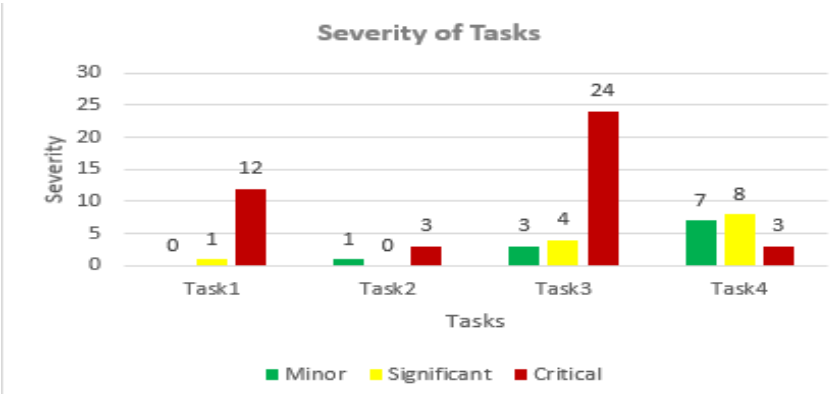

Figure 3. Severity of tasks

When the result is analyzed, 25% of the barriers are related to low contrast which is categorized as critical severity based on the barrier walkthrough method. Minor severity barriers represent 25% whereas the rest 50% corresponds to significant severity. The overall distribution of each barrier in all tasks is presented in Figure 4.

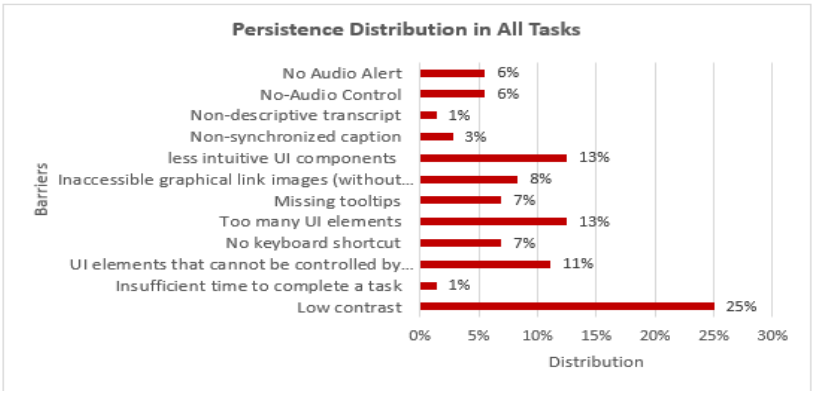

Figure 4. Persistence distribution in all tasks

5.2.2. Persistence Vs. Accessibility Principles

When we analyze the accessibility barriers based on accessibility principles, 61% of the total issues are related to perceivable, 32% belongs to operable, and the rest 7% belongs to understandable. Most of the accessibility barriers belongs to the accessibility principle of perceptibility. This is because 41% of less perceptible content results from low contrast and 20% of less perceptibility comes from less intuitive UI components. The use of automatic accessibility testing tools for contrast issues can solve the problem when a fully-fledged maternity learning and training application will be developed.

We have used only color codes as the only means to distinguish between UI elements and their functionalities which causes the 20% of accessibility issues related to perceptibility. This implies

that, the notion of distinguishing UI elements must consider other techniques in addition to color codes to develop an accessible multimedia training and learning application.

When we analyze the frequency of accessibility barriers (persistence) across the accessibility principles and a task, we get the figure depicted in Table 6. The first percentile represents the appearance of accessibility barriers in a $Task_n(T_n)$ that violates a given accessibility principle relative to all other accessibility barriers in a $Task_n$ whereas the second percentile represents the persistence of accessibility barriers relative to all other accessibility barriers that violates a given accessibility principle in all tasks (T_{ALL}).

Table 6. Analysis of persistence across accessibility principles

Task	**Perceivable**			**Operable**			**Understandable**		
	P	**relative to**		**P**	**relative to**		**P**	**relative to**	
		T_n	**T_{ALL}**		**T_n**	**T_{ALL}**		**T_n**	**T_{ALL}**
Task1	6	32%	14%	13	68%	57%	0	0	0
Task2	3	75%	7%	1	25%	4%	0	0	0
Task3	19	61%	43%	9	29%	39%	3	10%	60%
Task4	16	89%	36%	0	0	0	2	11%	40%

5.2.3. Persistence Vs. Number of UI Elements

Table 6. shows most of the accessibility barriers in each task are belongs to perceivable. This implies that people with low vision who have interacted with M2M had difficulties to percept UI components and their corresponding semantics despite they have used Windows Magnifier as assistive technology. In Task3, 43% of the barriers are belongs to perceivable compared to all other tasks. This is because the pages involved in Task3 (VC Home, VC Course List) have more number of UI elements compared to other pages in other tasks.

To study more, we compute the correlation between the persistence value and the number of UI elements in tasks. The data is summarized and presented in Table 7.

Table 7. Number of UI elements Vs. Persistence

Tasks	**Persistence**	**No of UI elements**
Task1	19	22
Task2	4	8
Task3	31	23
Task4	18	21

$$Correl\,(X,Y) = \frac{\sum(x-\bar{x})(y-\bar{y})}{\sum(x-\bar{x})^2\sum(y-y)^2} \quad \ldots\ldots(1)$$

As it is depicted in Figure 5, By applying (1), we get a correlation coefficient of 0.89 which shows a strong correlation between number of UI elements in a page and the frequency of accessibility barriers. This implies that the number of UI elements in a page should be relevantly small to make the UI/UX simple, intuitive, and more accessible.

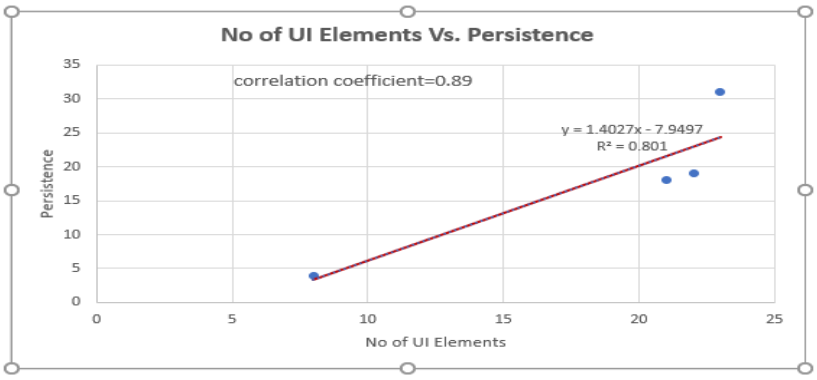

Figure 5. No of UI Elements Vs. Persistence

It is also observed that all the participants are familiar with the traditional user registration and login interfaces where they did report less accessibility barriers. However, they encountered more barriers in pages related to virtual classroom. The comparison between the traditional login and registration pages and non-familiar virtual classroom pages summarized in Figure 6. This implies that more emphasis needs to give to pages or interfaces that involves domain-specific and non-familiar functionalities in designing the UI/UX of the fully-fledged maternity training and learning application.

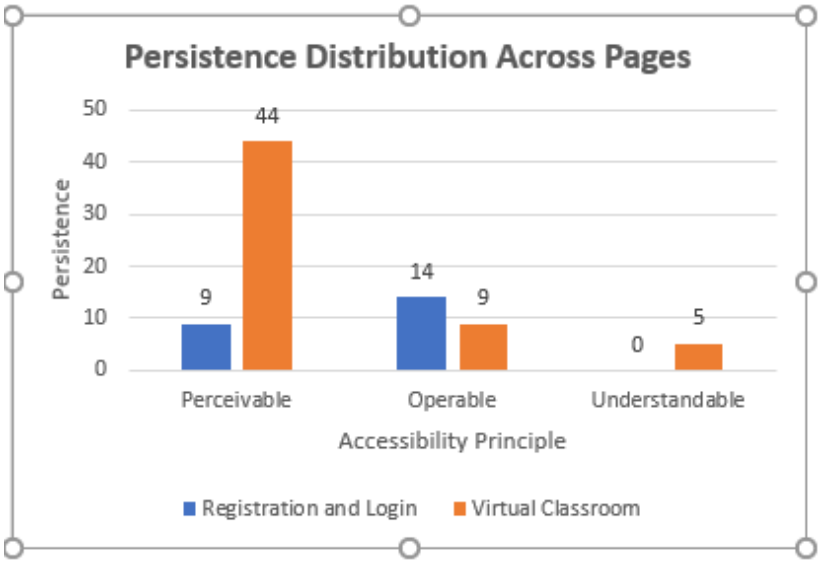

Figure 6. Persistence distribution across pages

We did not record any kind of accessibility barriers related to the robustness accessibility principle. This is because, we did not evaluate the prototype against different version of user agents.

5.2.4. Accessibility of The Multimedia Content

It is observed that the number of persistence increases when a task involves a multimedia content. As indicated in Table 5, 83% of the accessibility barriers are related to the multimedia content itself in Task4. It can be referred from Figure 6. that the multimedia content's transcript is hard to perceive due to low contrast of the text. This infers that the contrast of the transcript and caption

of a multimedia content must consider the contrast ratio to the page and the contrast ratio to the multimedia itself (the VR-based animation). For this reason, the accessibility of maternity multimedia needs to be evaluated independently before integrating it to the application.

Figure 7. Low contrast of transcript (red-circled) that makes hard to perceive content

5.3. Limitation of the Study

This study has several limitations related to the number and type of participants. We managed to participate only five users who all are midwives. Four out of five participants are Ethiopians, and the only other participant from Sub-Saharan Africa is Nigerian. In addition, we could not manage to participate local doulas in the evaluation of the prototype because of travel restrictions caused by the COVID-19 global pandemic. These all factors narrow our sample that may limit the significance of our study.

6. CONCLUSION AND FUTURE WORK

6.1. Conclusion

To design an accessible maternity training and learning application, the accessibility barriers of the target diverse user groups must be identified, and the impact of the barriers need to be quantified. In this research work, we have developed a prototype to identify the possible accessibility barriers of multimedia maternity health training and learning application experienced by people with low vision. We studied the severity of the identified accessibility barriers which serve as a benchmark to develop a fully-fledged learning and training application for maternity health.

This research work contributes in two directions. Our first contribution is the identification of accessibility barriers related to maternity health training and learning application and their severity that impacts performance parameters. Secondly, we have shown the strong correlation between the number of UI elements and the occurrence of accessibility barriers that must be taken in account in designing the UI/UX of the fully-fledged maternity training and learning applications.

6.2. Future Works

Despite our effort to develop a prototype that used to identify the accessibility barriers and their severity, there are still some important issues that must be addressed to develop a fully-fledged multimedia-based training and learning application for maternity health. We have summarized some of the future directions in this topic as follows:

- The evaluation of the prototype is done using the combination of barrier walkthrough, cooperative evaluation, and heuristics method by only considering people with low vision. Further study must be conducted in consideration of other diverse users and their situations.
- The prototype we have developed is a web application. The prevalence of mobile devices and the expansion of Internet infrastructure in the Sub-SaharanAfrica enabling people to access online training contents through their mobile devices. The identification and severity measurement of accessibility barriers related to maternity training and learning mobile applications requires further study.

REFERENCES

[1] UN: 'SDG3: Ensure healthy lives and promote well-being for all at all ages, Progress of goal 3 in 2019', 2019

[2] Asi, Y.M., and Williams, C.: 'The role of digital health in making progress toward Sustainable Development Goal (SDG) 3 in conflict-affected populations', International journal of medical informatics, 2018, 114, pp. 114-120. https://doi.org/10.1016/j.ijmedinf.2017.11.003

[3] Alamantariotou, K., and Nicolopoulou, K.: 'Knowledge Sharing in Health Innovation Projects: Experiential Learning from Collaborating in a Project-Based Working Group Focusing in Knowledge Transfer in Maternity Services Best Practice (COST Projects IS 0907)': 'mHealth Ecosystems and Social Networks in Healthcare' (Springer, 2016), pp. 159-169. https://doi.org/10.1007/978-3-319-23341-3_12

[4] Clark, R.C., and Mayer, R.E.: 'E-learning and the science of instruction: Proven guidelines for consumers and designers of multimedia learning' (John Wiley & Sons, 2016. 2016)

[5] Kreps, G.L.: 'Online information and communication systems to enhance health outcomes through communication convergence', Human Communication Research, 2017, 43, (4), pp. 518-530. https://doi.org/10.1111/hcre.12117

[6] Mayer, R.E.: 'Using multimedia for e-learning', Journal of Computer Assisted Learning, 2017, 33, (5), pp. 403-423. https://doi.org/10.1111/jcal.12197

[7] WHO: 'Stronger collaboration, better health: global action plan for healthy lives and well-being for all: strengthening collaboration among multilateral organizations to accelerate country progress on the health-related Sustainable Development Goals', 2019

[8] Black, R.E., Laxminarayan, R., Temmerman, M., and Walker, N.: 'Reproductive, Maternal, newborn, and child health: disease control priorities, (volume 2)' (The International Bank for Reconstruction and Development/The World Bank, 2016. 2016)

[9] Zhou, H., Zhang, L., Ye, F., Wang, H.-j., Huntington, D., Huang, Y., Wang, A., Liu, S., and Wang, Y.: 'The effect of maternal death on the health of the husband and children in a rural area of China: a prospective cohort study', PloS one, 2016, 11, (6). https://doi.org/10.1371

[10] Stanton, C.K., Rawlins, B., Drake, M., dos Anjos, M., Cantor, D., Chongo, L., Chavane, L., da Luz Vaz, M., and Ricca, J.: 'Measuring coverage in MNCH: testing the validity of women's self-report of key maternal and newborn health interventions during the peripartum period in Mozambique', PloS one, 2013, 8, (5). https://doi.org/10.1371

[11] Arbour, M.W., Nypaver, C.F., and Wika, J.C.: 'Innovative uses of technology in online midwifery education', Journal of midwifery & women's health, 2015, 60, (3), pp. 278-282. https://doi.org/10.1111/jmwh.12291

[12] Arcia, A., Stonbraker, S., and Warner, E.: 'Information Needs and Information-Seeking Processes of Low-Income Pregnant Women in Relation to Digital Maternity Education Resources', The Journal of Perinatal Education, 2019, 28, (3), pp. 151-162.

[13] Dianne, B.: 'Health communication: Theory and practice', in Editor (Ed.)^(Eds.): 'Book Health communication: Theory and practice' (London, Open University Press, 2007, edn.), pp.
[14] Marin, H., Massad, E., Gutierrez, M.A., Rodrigues, R.J., and Sigulem, D.: 'Global health informatics: how information technology can change our lives in a globalized world' (Academic Press, 2016. 2016)
[15] Northouse, P.G., and Northouse, L.L.: 'Health communication: a handbook for health professionals' (Prentice Hall, 1985. 1985)
[16] Schiavo, R.: 'Health communication: From theory to practice' (John Wiley & Sons, 2013. 2013)
[17] Jolivet, R.R., Moran, A.C., O'Connor, M., Chou, D., Bhardwaj, N., Newby, H., Requejo, J., Schaaf, M., Say, L., and Langer, A.: 'Ending preventable maternal mortality: phase II of a multi-step process to develop a monitoring framework, 2016–2030', BMC pregnancy and childbirth, 2018, 18, (1), pp. 258. https://doi.org/10.1186/s12884-018-1763-8
[18] United Naitons, D.o.E.a.S.A.: 'SDG Golas: SDG Indicators', 2019
[19] Alkema, L., Chou, D., Hogan, D., Zhang, S., Moller, A.-B., Gemmill, A., Fat, D.M., Boerma, T., Temmerman, M., and Mathers, C.: 'Global, regional, and national levels and trends in maternal mortality between 1990 and 2015, with scenario-based projections to 2030: a systematic analysis by the UN Maternal Mortality Estimation Inter-Agency Group', The Lancet, 2016, 387, (10017), pp. 462-474. https://doi.org/10.1016/S0140-6736(15)00838-7
[20] Tessema, G.A., Laurence, C.O., Melaku, Y.A., Misganaw, A., Woldie, S.A., Hiruye, A., Amare, A.T., Lakew, Y., Zeleke, B.M., and Deribew, A.: 'Trends and causes of maternal mortality in Ethiopia during 1990–2013: findings from the Global Burden of Diseases study 2013', BMC public health, 2017, 17, (1), pp. 160. https://doi.org/10.1186/s12889-017-4071-8
[21] Fagbamigbe, A.F., and Idemudia, E.S.: 'Barriers to antenatal care use in Nigeria: evidences from non-users and implications for maternal health programming', BMC pregnancy and childbirth, 2015, 15, (1), pp. 95. https://doi.org/10.1186/s12884-015-0527-y
[22] Rate, A.F.: 'Democratic republic of congo', 2017
[23] Lee, H., Park, S.J., Ndombi, G.O., and Nam, E.W.: 'Community-based maternal and child health project on 4+ antenatal care in the Democratic Republic of Congo: a difference-in-differences analysis', Reproductive health, 2019, 16, (1), pp. 1-10. https://doi.org/10.1186/s12978-019-0819-1
[24] Wijeratne, D., and Weeks, A.D.: 'Reducing maternal mortality in sub–Saharan Africa: the role of ethical consumerism', Journal of global health, 2017, 7, (1). doi: 10.7189/jogh.07.010309
[25] Ganle, J.K., and Dery, I.: ''What men don't know can hurt women's health': a qualitative study of the barriers to and opportunities for men's involvement in maternal healthcare in Ghana', Reproductive health, 2015, 12, (1), pp. 93. https://doi.org/10.1186/s12978-015-0083-y
[26] Munguambe, K., Boene, H., Vidler, M., Bique, C., Sawchuck, D., Firoz, T., Makanga, P.T., Qureshi, R., Macete, E., and Menéndez, C.: 'Barriers and facilitators to health care seeking behaviours in pregnancy in rural communities of southern Mozambique', Reproductive health, 2016, 13, (1), pp. 31. https://doi.org/10.1186/s12978-016-0141-0
[27] Kambala, C., Morse, T., Masangwi, S., and Mitunda, P.: 'Barriers to maternal health service use in Chikhwawa, Southern Malawi', Malawi medical journal, 2011, 23, (1)
[28] Cole, C.B., Pacca, J., Mehl, A., Tomasulo, A., van der Veken, L., Viola, A., and Ridde, V.: 'Toward communities as systems: a sequential mixed methods study to understand factors enabling implementation of a skilled birth attendance intervention in Nampula Province, Mozambique', Reproductive health, 2018, 15, (1), pp. 132. https://doi.org/10.1186/s12978-018-0574-8
[29] Steel, A., Frawley, J., Adams, J., and Diezel, H.: 'Trained or professional doulas in the support and care of pregnant and birthing women: a critical integrative review', Health & social care in the community, 2015, 23, (3), pp. 225-241. https://doi.org/10.1111/hsc.12112
[30] Wang, T.j. Educational Benefits of Multimedia Skills Training. TECHTRENDS TECH TRENDS 54, 47–57 (2010). https://doi.org/10.1007/s11528-009-0363-x
[31] Lau, R.W., Yen, N.Y., Li, F., and Wah, B.: 'Recent development in multimedia e-learning technologies', World Wide Web, 2014, 17, (2), pp. 189-198. https://doi.org/10.1007/s11280-013-0206-8
[32] Merchant, Z., Goetz, E.T., Cifuentes, L., Keeney-Kennicutt, W., and Davis, T.J.: 'Effectiveness of virtual reality-based instruction on students' learning outcomes in K-12 and higher education: A meta-analysis', Computers & Education, 2014, 70, pp. 29-40. https://doi.org/10.1016/j.compedu.2013.07.033

[33] Abdelaziz, M.A., Alaa El Din, M., and Senousy, M.B.: 'Challenges and issues in building virtual reality-based e-learning system', International Journal of e-Education, e-Business, e-Management and e-Learning, 2014, 4, (4), pp. 320
[34] Lee, E.A.L.: 'An investigation into the effectiveness of virtual reality-based l earning', Murdoch University, 2011
[35] Merdad, L., and Ali, M.M.: 'Timing of maternal death: levels, trends, and ecological correlates using sibling data from 34 sub-Saharan African countries', PLoS One, 2018, 13, (1), pp. e0189416
[36] Zhang, P., and Galletta, D.F.: 'Foundations of human-computer interaction in management information systems: an introduction': 'Human-computer interaction and management information systems: foundations' (Routledge, 2015), pp. 15-32
[37] McElroy, K.: 'Prototyping for designers: Developing the best digital and physical products' (" O'Reilly Media, Inc.", 2016. 2016)
[38] Acosta-Vargas, P., Salvador-Ullauri, L.A., and Luján-Mora, S.: 'A heuristic method to evaluate web accessibility for users with low vision', IEEE Access, 2019, 7, pp. 125634-125648
[39] Yesilada, Y., Brajnik, G., and Harper, S.: 'How much does expertise matter? A barrier walkthrough study with experts and non-experts', in Editor (Ed.)^(Eds.): 'Book How much does expertise matter? A barrier walkthrough study with experts and non-experts' (2009, edn.), pp. 203-210. https://doi.org/10.1145/1639642.1639678
[40] Benyon, D.: 'Designing interactive systems: A comprehensive guide to HCI, UX and interaction design', 2014
[41] Sears, A.: 'Heuristic walkthroughs: Finding the problems without the noise', International Journal of Human-Computer Interaction, 1997, 9, (3), pp. 213-234. https://doi.org/10.1207/s15327590ijhc0903_2

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