University of Zurich[UZH]

UNIVERSITY OF ZURICH

DEPARTMENT OF INFORMATICS

BACHELOR THESIS IN INFORMATICS

Remote E-Learning – Development of a tablet solution to support learning for community health workers in Lesotho

Silvan Kübler
19-752-906
silvan.kuebler@uzh.ch

Supervisor
Prof. Dr. Gerhard Schwabe
Information Management Research Group

Responsible Assistant
Dario Stähelin

Submission Date
18.07.2022

Abstract

This thesis comes up with a solution for e-learning in a community-based healthcare project conducted by ComBaCaL (Community Based Chronic Care) in Lesotho. Community-based healthcare is common in low- and middle-income countries due to the lack of physicians and often far distances to cover. Hence, health care is provided by CHWs (Community Health Workers) which most of the time only receive their initial training and are afterwards sent to the field. In place, physical training is expensive and requires a lot of effort and time from all stakeholders. This lack of continuous training leads to lower efficiency, safety and quality of the services provided by the CHWs. With the help of e-learning, new approaches are possible. During this thesis, e-learning requirements in the specific context of ComBaCaL are determined and multiple potential solutions are evaluated. The chosen solution is implemented and tested in a field experiment. Data is collected in the form of questionnaires and usage statistics. The participants show a high level of interest in the solution and agree that it provides great added value for them personally considering their ability to learn apart from the physical training sessions. As a result, there are suggestions for improvement within the application and challenges considering its further integration into ComBaCaL, which must be considered with the future scaling of the project.

Zusammenfassung

In dieser Arbeit wird eine E-Learning Lösung innerhalb eines gemeinschaftsbasiertem Gesundheitsprojekt von ComBaCaL (Community Based Chronic Care) in Lesotho entwickelt. Die gemeinschaftfsbasierte Gesundheitsversorgung ist in Ländern mit niedrigem und mittlerem Einkommen weit verbreitet, da es an Ärzten mangelt und oft große Entfernungen zu überwinden sind. Daher wird die Gesundheitsversorgung von CHWs (Community Health Workers) geleistet, die meist nur eine Grundausbildung erhalten und dann ins Feld geschickt werden. Die physische Ausbildung ist teuer und erfordert von allen Beteiligten viel Mühe und Zeit. Dieser Mangel an kontinuierlichem Training führt zu einer geringeren Effizienz, Sicherheit und Qualität der von den CHWs erbrachten Leistungen. Mit Hilfe von E-Learning sind neue Ansätze möglich. Im Rahmen dieser Arbeit werden die Anforderungen an E-Learning im spezifischen Kontext von ComBaCaL ermittelt und mehrere potenzielle Lösungen evaluiert. Die ausgewählte Lösung wird implementiert und in einem Feldexperiment getestet. Die Daten werden in Form von Fragebögen und Nutzungsstatistiken erhoben. Die Teilnehmer zeigen ein hohes Interesse an der Lösung und sind sich einig, dass für sie persönlich das E-Learning einen großen Mehrwert in Bezug auf ihre Lernfähigkeit abseits der physischen Trainingseinheiten darstellt. Daraus ergeben sich Verbesserungsvorschläge für die Anwendung und Herausforderungen im Hinblick auf ihre weitere Integration in ComBaCaL, die bei der zukünftigen Skalierung des Projekts berücksichtigt werden müssen.

Acknowledgement

I would like to take this opportunity to thank everyone who has supported me in my work in any way.

First of I want to thank Prof. Dr. Schwabe for giving me the opportunity to write a thesis that is highly practical and has a real-world impact at his chair the IMRG.

Second, I want to thank my supervisor Dario Stähelin for working so closely together with me during the whole thesis. He was always giving me very helpful inputs and assistance when I had questions and did a great job connecting me with the relevant stakeholders inside ComBaCaL.

Further thanks to Steve Mc Crosky and Felix Gerber for the commitment and immense help for the collaboration on the creation of learning content. They were able to assist and help me perfectly to fill the gaps in my knowledge from a medical standpoint.

I want to thank Josh from Medic in helping me setup CHT locally on my machine.

A big thank you to Alex from Digital Campus who helped me with all the questions I had around OppiaMobile and offered the use of their Moodle for the creation of courses for no cost at the time being.

A special thank you to Thabo Ishmael for introducing OppiaMobile in the field and providing on the spot assistance around any technical difficulties that occurred.

Thank you to all the interviewers and staff that helped to introduce the application in Lesotho.

Special thanks to all community health workers inside the project for testing and using the application and giving their feedback on it. Without them such a good testing and evaluation of results could not have been accomplished.

I want to thank Ursula Kübler and Corey Bothwell for proofreading my final thesis.

Finally, I want to thank Joel Weber and Nicolas Peyer my fellow friends they always had an open ear for my problems, doubts and ideas and gave me their much appreciated opinion from a student's perspective.

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Abbreviations

ComBaCaL	Community Based Chronic Care Lesotho
IMRG	Information Management Research Group
Swiss TPH	Swiss Tropical and Public Health Institute
CHW	Community health worker
NCD	Non communicable disease
CHT	Community Health Toolkit
Moodle	Modular Object-Oriented Dynamic Learning Environment
e-learning	electronic learning
m-learning	mobile learning
eHealth	electronic health
AWS	Amazon Web Services
AMI	Amazon Machine Images
EC2	Elastic Compute Cloud
SQL	Structured Query Language
HTML	Hypertext Markup Language
UI	User Interface
API	Application Programmable Interface

1 Introduction

1.1 Motivation

CHWs are a proven concept in low- and middle-income countries to support the overburdened health system by providing primary health care directly to the community. CHWs have been used very successfully to combat HIV/AIDS in Africa (Schneider et al., 2008). They take on tasks such as screening and diagnosis of diseases and are trained to do so in a short period of time. Approaches based on reciprocal CHW training have proven to be beneficial in the past (Josiah Willock et al., 2015). Following these very rudimentary trainings, CHWs are directly deployed to the field. Although refresher trainings are conducted intermittently at larger intervals, access to training material is generally lacking or, if available, often outdated, or incomplete. One possible consequence of these deficiencies in training is the gradual decline in the quality of health services provided by CHWs. Hence there is an urgent need for new approaches.

E-learning is one of these new approaches with great potential. In this bachelor thesis an e-learning approach is implemented and tested within an existing project called ComBaCaL (Community Based Chronic Disease Care Lesotho). The ComBaCaL project includes the CHT application, which aims to facilitate the diagnosis and treatment of chronic diseases such as diabetes and hypertension in Lesotho. Diagnosis and treatment are largely provided by CHWs, who undergo only brief medical training.

In this thesis, initially the potential of e-learning within the context of ComBaCaL is evaluated. This is performed via literature analysis around e-learning and discourse with stakeholders within the project. Thereafter, various possible e-learning solutions are analyzed in more detail. In a next step, a solution is chosen and implemented, based on the collected information. During this process, a continuous dialogue with various stakeholders from ComBaCaL is maintained, in order to refine the learning material which should be available. In a final step, the solution is field tested in Lesotho by CHWs of the pilot study.

1.2 Research Questions

The following research questions are answered in this thesis:

- What opportunities does e-learning offer for continuous and "individualized" training of CHWs?
    - What are the requirements of the relevant stakeholders for e-learning?
    - How can existing e-learning tools be integrated into ComBaCaL and, if necessary, extended?
    - How can e-learning be integrated into ComBaCaL using the example: "Repetition of basic training"?

1.3 Structure of the Thesis

Phase 1: Familiarization, discussion with stakeholders and problem scenarios ("Problem identification and motivation")

To identify the problem, the student works through the literature on "community-based health care" and previous project material. Both are partially available within ComBaCaL.
To solve the problem, the student familiarizes himself with research papers on topics such as "E-learning in developing countries", "E-learning for medical education" and "Successful models for e-learning".

The student gets to know the CHT application and attaches particular importance to the module "Remote Training". This is a possible solution for e-learning in a later phase. In addition, experts of the project are consulted regarding their visions around e-learning within ComBaCaL. These experts are from Swiss TPH: Steve McCrosky and Felix Gerber, from Lesotho: Thabo Ishmael and from IMRG: Dario Stähelin.

Deliverable: Problem scenarios and e-learning requirements based on the aggregated information.

Phase 2 & 3: Evaluation of different e-learning solutions

Different possible e-learning solution approaches are evaluated based on the requirements from phase 1.

Deliverable: E-learning solution approach

Phase 4: Presentation of the e-learning solution to the stakeholders of ComBaCaL

The e-learning solution approach is presented to the stakeholder of ComBaCaL consisting of experts from the IMRG, Swiss TPH and Lesotho in a short presentation. The resulting suggestions for improvement are discussed and if possible incorporated into the prototype.

Deliverable: Production ready e-learning solution

Phase 5: Integration into ComBaCaL

The prototype is integrated into ComBaCaL by the student. This requires guides on how to setup and use the application. Instructions are given directly to the responsible person for e-learning in Lesotho. In a short online presentation, the e-learning solution is directly presented and introduced to the CHWs.

Deliverable: Guides and a plan for the introduction in Lesotho

Phase 6: Field testing

The e-learning solution will be field tested in Lesotho with 10 CHWs from the pilot study. This is done in the context of evaluation in the ComBaCaL project and is organized in cooperation with the project team. The application is tested and feedback in various forms is collected.

Deliverable: Analysis of collected data with suggestions for improvement in a next project phase.

Phase 7: Communication

In this phase, the research results from the previous phases and the development are documented in the form of a scientific paper.

Deliverable: Scientific paper

2 Related Work

In this chapter related work concerning the thesis is presented. It demonstrates the current state of knowledge in the scientific community and serves as the foundation in which this thesis builds upon.

2.1 Noncommunicable disease (NCD)

According to the WHO a noncommunicable disease is defined as follows: "Noncommunicable diseases (NCDs), also known as chronic diseases, tend to be of long duration and are the result of a combination of genetic, physiological, environmental and behavioral factors" (WHO, 2021). The four primary categories of NCDs include diabetes, cancer, chronic respiratory disorders and cardiovascular diseases (WHO, 2021). Unhealthy behavior like unhealthy nutrition, lack of physical activity, tobacco and alcohol often result in NCDs (Krishnan et al., 2011). "NCDs disproportionately affect people in low- and middle-income countries where more than three quarters of global NCD deaths – 31.4 million – occur" (WHO, 2021). In order to lower this number in the future it is unavoidable to promote a healthy lifestyle, as well as conduct early screening accompanied with regular treatment, based on the screening results (Yaya et al., 2018).

ComBaCaL is a project between Switzerland and Lesotho that aims to develop, test and share new approaches considering NCDs in rural Africa.

2.2 Community-based health care

In the western world the community-based health care model is rarely used due to the superior healthcare system with numerous physicians and specialists which are generally widely available. Thanks to insurance treatment is affordable to almost everyone, independent of their income and social status. However, this changes rapidly if one looks at developing countries, mostly in Asia or Africa. In comparison, Switzerland has about 4.3 physicians per 1000 inhabitants, whereas in Lesotho this number results to only 0.1 (*Physicians (per 1,000 People) | Data*, n.d.). This makes it practically impossible that everyone can be treated regularly by a physician. This is not the only problem. Furthermore, the lower average incomes, the often huge distances between physicians and patient and lack of public transport are important negative factors too. This all results in an insufficient health care system which is not optimal for the public. Luckily, over the years the community-based health care system has been developed and helps to reduce the burden on the public health care. The ComBaCaL project which is funded by the Swiss Development Cooperation (SDC) and the World Diabetes Federation (WDF), also takes the community-based health care approach (*ComBaCaL*, n.d.). Concretely diagnosis and treatment are done in remote villages by CHWs which are supported by an eHealth application.

Community-based health care systems rely on lay persons to provide primary health care for diseases such as HIV, malaria and tuberculosis (Perry et al., 2014). The most critical resource is the availability of CHWs.

2.3 Community Health Workers (CHWs)

CHWs take on a very important role in the setting of community-based health care. Perry et al. (2014) show that in low income countries CHWs are often used to provide care in health priority areas, such as the treatment of childhood malnutrition, improving maternal and child health. CHWs have shown to be of utter importance in countries where health workforce resources are limited and access is spare.

Most CHWs have in common that they work in communities not directly related to health facilities and have gone through formal but short training before their deployment to the field (Perry et al., 2014). Their workplace is directly in people's homes, neighborhoods, communities and other nonclinical spaces (Perry et al., 2014). According to Tulenko et al (2013) CHWs are often neglected when the health workforce is planned. This leads directly to lower efficacy and weakened synergies. Further, the problem of multiple actors with lack of coordination manifests itself as a large problem, since there are often multiple competing CHW approaches within one district and joint communication on government level is often completely nonexistent. Thus the responsibilities of CHWs are often not clear and it is not obvious if they represent the community, an NGO, the health system or a combination of these (Tulenko et al., 2013). These are all important problems that also apply within ComBaCaL.

ComBaCaL takes over the training of CHWs and evaluates the data collected from the screening and diagnosis on a large-scale to find out what aspects of NCD care CHWs can takeover without large losses in efficacy and safety (*ComBaCaL*, n.d.).

In the context of this thesis, the lack of in-depth training and repetition should be especially considered. This directly leads to a decline in the quality of the provided care by the CHWs. Repeated learning is important and has a long research history. Ausubel & Youssef (1965) have shown in their study that a group which repeated the learning material had better retention than the group with no repetition.

2.4 eHealth

With the ubiquity of digital devices and especially mobile devices, eHealth is more and more becoming ubiquitous as shown by the numbers. It is a 14.7 billion dollar market in the year 2022 and will grow by approximately 14.8% until 2026 (Market Data Forecast, 2022). Cunningham et al. (2014) define eHealth as follows: "Electronic Health, or 'eHealth', is the term used to describe interactions with health services that can be performed using computer-based communication technologies. It evolved from telemedicine and tele-health where telecommunication is the delivery method for health care". Many different stakeholders from clinical personnel to patients can be supported by eHealth and there are few limits to its application (Cunningham et al., 2014). This summarizes the term eHealth; however many alternative definitions can be found and are also possible.

The number one goal of eHealth is to allow for better and more efficient services and treatment (Cunningham et al., 2014). They do so by providing consistency in the best practice implementation

which results in improved clinical outcome (Cunningham et al., 2014). Further eHealth allows for more patient involvement and by that giving the patient the opportunity to be more responsible for its own health (Cunningham et al., 2014). It is mostly used on personal computers, mobile phones or tablets (Cunningham et al., 2014). This makes eHealth perfect for the ComBaCaL project because mobile devices are widely available even in the most remote environments. The Community Health Toolkit (CHT) is used in ComBaCaL as an eHealth solution. CHT is an association of which the primary goal is to support the development of digital health in remote locations (*Community Health Toolkit*, n.d.).

But like any other system, eHealth does have a few challenges. Cunningham et al. (2014) name a few: There exists technology phobia and the diversity of patients which can lead to significant barriers in using eHealth applications. The systems should be designed to reduce barriers and not to create new ones, for this e.g., screen readers and adjustable font-size can be implemented. Most likely, there is almost always a language barrier and more than one primary language is spoken in a specific field where the eHealth system is implemented. In this case it is very important that localization is offered.

CHT addresses these problems in their vision as follows: "Together, we envision a world where healthcare is of the highest attainable quality, equitable, accessible, and delivered by people who are trusted in their communities." (*Community Health Toolkit*, n.d.). Whereas frameworks such as CHT do a good job considering eHealth, the continuous training and education of the CHWs are often neglected or not considered at all. Discussions within the ComBaCaL team have shown that this is important to ensure efficacy and safety of the services provided and finally help minimizing the churn rate by providing an interesting and challenging work environment where CHWs can educate themselves further.

2.5 E-learning and M-learning

With the rise of computers and the internet, electronic learning (e-learning) has quickly become a widely discussed topic. According to Kumar Basak et al. (2018) e-learning is at the same time both an alternative and a complement to traditional education. M-learning is a subgroup of e-learning which allows learning outside of one's normal environment on a mobile device such as a smartphone or tablet. Further, m-learning is characterized by highly tailored learning content, more personalization and interaction than found in traditional e-learning (Klímová, 2018).

According to Kumar Basak et al. (2018) this opens up three perspectives in the case of m-learning namely mobility of technology, mobility of learning, and mobility of the learner.

The mobility of the technology considers mobile devices such as smartphones and tablets that are utilized to deliver instructional and educational content for the learner regardless of its location (Traxler & Kukulska-Hulme, 2007). Connectivity is guaranteed by telephone networks, Wi-Fi and Bluetooth and can be used with services like social media, email and SMS (Kothamasu, 2010).

Mobility of learners refers to the independence of time and place which opens up the opportunity that learners from different places and time zones can interact with each other (Traxler & Kukulska-Hulme, 2007).

Mobility of learning also enables a powerful learning experience by giving learners the chance to move into professional, social, intercultural, and interpersonal competencies rather than staying in the everyday context (Kumar Basak et al., 2018).

2.5.1 M-learning in development countries

Almost 50% of the people in emerging economies owned a smartphone in 2018, this represents an increase by 30% in just six years (Silver, 2019). This trend will likely continue, and we can expect even higher numbers in the future. Therefore, it is a logical consequence that m-learning is also growing rapidly. M-learning is an important new pillar of education in development countries due to the often inadequate resources surrounding traditional education. Although its path may differ from the western one as Traxler & Kukulska-Hulme (2007) state: "It is entirely possible that the emergence of mobile learning in developing countries will take the evolution of e-learning along a trajectory that is very different from that in developed countries, where it has been predicated on massive, static, and stable resources." Concluding, m-learning is on the rise in developing countries but there are many challenges which need to be adequately addressed. A special case of m-learning is its application in the medical field.

2.5.2 M-learning for medical education

Most m-learning done today is in the form of assessments where the learner is presented a single question and multiple answers to choose from; after selecting the answer the user receives immediate feedback in the form of "correct" or "incorrect" (Walsh, 2015). This gives the learner the opportunity to learn small chunks of questions at a time; they are not forced to learn for hours (Walsh, 2015). This results in more frequent but shorter learning sessions. Klímová (2018) has shown that among medical students the use of a mobile device or app has positive effect on skills and acquisition of knowledge. This is mostly due to the fact that medical students are anyway using mobile devices in their daily lives and are therefore willing to use them for their education too. Sena et al. (2013) have found that mobile devices coupled with learning applications have proven to be efficient in learning new medical procedures. Practice behavior improved for practitioners when managing a disease after using m-learning (Schopf & Flytkjær, 2012). M-learning should not be used alone but rather as supplementary to traditional learning techniques such as in person learning. This way it contributes more to the enhancement, retention, and facilitation of skills and knowledge (Klímová, 2018). As with any technology, m-learning does have some challenges and drawbacks.

2.5.3 Challenges in m-learning

There are quite a few challenges that need to be addressed when considering m-learning: Some technical constraints include: lack of internet connection, price of the device, small screen size of mobile devices, limited memory and battery, technical problems and security issues (Klímová, 2018).

With the use of mobile phones there is always the risk of distraction through SMS or social media applications (Crescente & Lee, 2011). This problem can however be solved at least partly in the ComBaCaL project by using a separate device only for the ComBaCaL related work.

The high availability of mobile devices may have a negative impact on the time spent on the mobile phone, whereas some people could tend to overuse or develop unhealthy usage habits when considering usage hours of the m-learning application (Sandars et al., 2010).

According to Trifonova & Ronchetti (2003), m-learning is a powerful tool, but it should never be forgotten that the concept and objectives are always more important than a new technology. Further m-learning does not substitute a teacher, content creator or supervisor.

Crescente & Lee (2011) state that the cost of m-learning often is a double-edged sword. On the one hand costs for classrooms, printed material, teachers can be minimized, but on the other hand there is an increase in cost for creating the m-learning application, new or reformulated learning material, costs for testing and for devices themselves. Costs can also increase with hardly predictable events such as compromised IT security due to malware in the system, because of bad software engineering and/or poorly maintained applications or security vulnerabilities. When m-learning applications contain, sensitive data, it must be ensured that data security has a high priority in the project.

Often, when m-learning is to be implemented in a country where people are not that experienced with mobile devices, this unfamiliarity can become a problem while using the device and its software (Mohammad et al., 2012). Out of this evolves the special requirements of the UI/UX that should address these issues.

Considering the learning material, applications must be culturally appropriate to be sensitive to cultural norms and not be offensive, this means that localization in the form of language, symbols and images should be done (Mohammad et al., 2012, p.).

M-Learning can potentially lead to isolation, separation or to "feeling-out-of-the-loop" due to the lack of physical engagement with other learners (Sarrab, 2012). This can be overcome by creating a space where learners can communicate with each other. Most likely this will also have a positive impact on the retention and understanding of the learned material.

3 Methodology

3.1 Design Science Research (DSR)

Within the thesis the method "Design Science Research" by (Peffers et al., 2007) is used. DSR generates an IT artifact based on scientific theory and practical relevance. The iterative approach enables and encourages communication between stakeholders. This aspect makes DSR the appropriate method for this thesis due to the many stakeholders and the integration into a practical project.

The DSR methods consists of six activities (Peffers et al., 2007):

Activity 1 "Problem identification and motivation": The problem is formulated and the generated value of solving it is demonstrated.

Resources: Knowledge is needed regarding the status of the problem and the importance of its solution.

Activity 2 "Define the objectives for a solution": Objectives are defined in terms of a solution. These objectives can be quantitative as well as qualitative in nature. They are derived from the problem specification through a rational process.

Resources: Knowledge about the status of the problems and their current solution.

Activity 3 "Design and Development": The artifact is created. This is an object in the form of a construction, model, or method that is created based on research input.

Resources: Knowledge of theory relevant to be incorporated into the solution artifact.

Activity 4 "Demonstration": The artifact is used to solve the previously identified problem in the context of a demonstration. This can be the use in an experiment, a simulation, a case study, a proof, or other appropriate activities.

Resources: Knowledge of how to use the artifact to solve the problem.

Activity 5 "Evaluation": The extent to which the artifact contributes to solving the problem is observed and measured. This involves comparing the goals of a solution with the actual observed results of using the artifact in the demonstration.

Activity 6 "Communication": The problem, the artifact with its relevance and application, and its effectiveness are communicated to researchers. This is usually done in the context of a scientific paper.

The whole process is iterative and thus it is possible to start at any sub-activity at each further iteration.

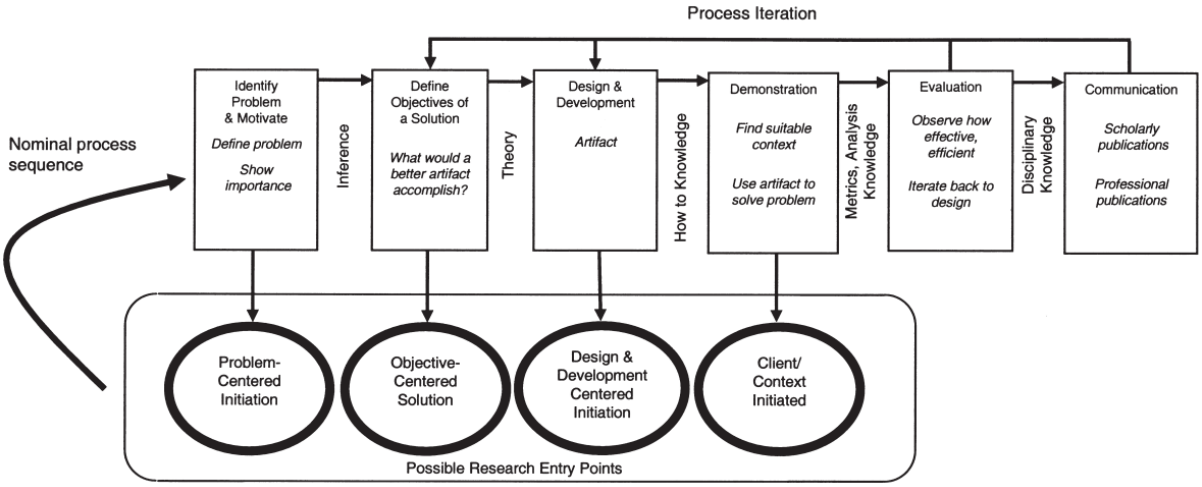

Figure 1 Design Science Research Model (Peffers et al., 2007).

4 Artifact

The artifact is the result of analysis of the scientific related work and own evaluations. The artifact is in the form of an open source mobile application.

4.1 Problem Scenarios

The following problem scenarios were identified after the literature analysis and discussions with different stakeholders from ComBaCaL.

4.1.1 Village Health Worker Program

Vaughan & Walt (1983) state that village health workers provide primary health care to almost everyone. They act as a link between the community and the government considering health care and often do their job for a small monetary incentive. They must be differentiated from other primary health workers such as nurses and medical assistants.

During my discussions with the person responsible for eHealth inside ComBaCaL, additional topics arose: In Lesotho village health workers currently exist with the purpose to promote health rather than to diagnose and treat. This approach was perceived to work in an acceptable manner before further investigation from ComBaCaL members. Later it was discovered that quite a few problems exist with the current program and that it works rather poorly. Village health workers enter retirement or die due to age and are not replaced by new forces. This leads to unsatisfactory circumstances where the coverage and services provided by village health workers both decline. Training and updates are also managed poorly or not at all. Village health workers often receive no further training after their initial training at all. From time to time they must hand in some physical reports on how their work is going. These reports must be handed-in in person and are then stored in an archive and most likely forgotten. Village health workers feel neglected by the ministry of health. They act as a link between the community and the government surrounding health care and often do their job for a small monetary incentive but do not receive any further attention apart from that.

4.1.2 In-Person Training

CHWs receive their initial training in-person. The training lasts one week; accommodation is provided by ComBaCaL because distances are too far to travel twice a day. Road conditions make driving in the darkness too dangerous. This results in high costs for ComBaCaL, which is not optimal. The training consists of two main parts: In the first part, CHWs learn how to conduct simple medical measurements like blood sugar and blood pressure based on theoretical material mostly on paper. In a next phase, the aspiring CHWs take part in role plays, where they simulate a screening scenario using the CHT application on their tablet. This serves to familiarize them with the app and to help gain experience with real world scenarios.

The problems with in-person training are logistical in nature: High costs and long distances result in a heavy burden for CHWs and ComBaCaL to organize a training.

4.1.3 Different education basis

Working and learning together is required in an in-person training environment. This can however become quite difficult with the different educational backgrounds among the CHWs. Some have a solid school or even university education, whereas others only have a very basic foundation. This, joint with the differences in receptivity, makes it difficult to provide a pleasant and uniform training experience for all CHWs at the same time.

4.1.4 Old training material

The official guidelines for diabetes from the ministry of health in Lesotho are from the year 2006 and with this not up to date with the latest scientific and medical findings anymore.

4.1.5 Information storage

Storing the training material can be quite a challenge for CHWs. Although they treat the material very carefully, material on paper is often destroyed or lost within days. Most of the time this material is also available as a PDF in their email inbox, but here other technical difficulties exist. CHWs may not know how to open a PDF.

These problem scenarios are the foundation of the following requirements that the m-learning solution should fulfill.

4.2 M-Learning solution requirements

The following requirements were identified based on the above problem scenarios and are supplemented by information retrieved from multiple discussions with the various stakeholders from ComBaCaL, primarily with people from the Swiss TPH and IMRG. These requirements should be considered when deciding on the m-learning prototype solution:

- Must be energy efficient, because CHW often do not have electricity available 24/7.
- The application must be usable for a user with little mobile device experience.
- An offline first approach, due to sometimes bad or no internet connection for longer periods of time.
- Creation of new content should be feasible without programming knowledge.

- Feedback must be "in-the-loop". That is to say that the material must be not only self-contained, but it should also incorporate a way to validate the learned material and give the CHW an objective response considering their performance.
- Gamification e.g., in form of a score, or different levels that can be achieved. This also serves as the foundation for the possibility that CHWs can compare their mastery of the material to others.
- Reusing content that has already been created by other projects, regarding their license, should be possible.

4.3 Analysis of possible solutions

As with any project, many possible solutions are possible and the best one for the specific use case of ComBaCaL must therefore be evaluated.

4.3.1 OppiaMobile

"OppiaMobile is an open source mobile learning platform specially designed for delivering learning content, multimedia and quizzes in low-broadband settings", (*OppiaMobile – Digital Campus*, n.d.). As stated by *OppiaMobile – Digital Campus* (n.d.) a further advantage is the built-in gamification aspects. This includes features for earning points and badges when completing activities and courses. Automatic notifications in the event of course updates are available and multilanguage support is available out of the box.

For supervisors, OppiaMobile offers the ability to get an insight into the students' performance e.g., see quiz scores, which content has already been successfully passed and much more.

For course authors, OppiaMobile offers the creation and collaborative editing of learning material inside Moodle, an open source e-learning platform. This brings the big advantage that for course authors no programmatic knowledge is necessary. It suffices if one is able to use the user interface. Further, course and quiz updates can be pushed automatically to the users using the Moodle and OppiaMobile integration.

For administrators, there is an online dashboard that provides an overview over activities on the platform. Additionally, devices can be managed remotely in regard to locking or wiping data through the Admin API.

OppiaMobile and CHT can be integrated to a certain degree. There is the opportunity to link courses and modules directly inside CHT. When clicking on this link inside CHT, the OppiaMobile application and the respective course are opened automatically.

Advantages:

- Designed for mobile learning

- Deployment through Amazon web services
- Fully customizable back- and frontend
- Gamification built-in
- Courses can be edited in Moodle
- Offline first approach
- Proven across many projects
- Data is segregated from the rest of CHT (less susceptibility to failure)

Disadvantages:

- Data is segregated from the rest of CHT (harder to achieve performance based learning)
- Separate application from CHT
- Higher cost than a single application regarding maintenance and hosting
- User needs to become familiar with a new application
- A new account is needed separate from CHT
- Performance learning based on user input will be much harder to achieve, because of two separate applications
- Moodle needs to be hosted separately
- Technical differences between CHT and OppiaMobile make it harder for developers because they must know many different technologies
    - CHT uses JavaScript in the frontend and backend, CouchDB as database
    - OppiaMobile uses Java in the frontend and Python in the backend

4.3.2 XForms in CHT & customized extension

Remote Onboarding and Training (2020) is a CHT functionality that leverages the existing CHT features like tasks, forms and targets to provide m-learning to CHWs. Customized training modules can be created and rolled out. Further, it is possible to evaluate the knowledge levels from the training material through special assessments and to identify CHWs who may need extra help from their supervisor. The training can be done directly through the CHT application or via the integrated SMS service.

For supervisors, the remote training integration allows them to verify if CHWs have completed the training successfully and if not, they can intervene.

For course authors, new courses can be created with the help of XLSForms. These forms consist of spreadsheets similar to excel, where a certain structure must be used. But there are additional programmatic features like conditional statements and variables. The functionalities and syntax of XLSForms must be learned by the course author and are not very straightforward, as there is no syntax highlighting or other help directly in the spreadsheet.

Advantages:

- Integrates nicely into CHT
- Leverages CHT core
- One single application
- Same technology stack as CHT
- Same deployment as CHT
- Material and assessment created through XLSForms
- Offline capability
- Targets function like "gamification" could possibly be extended by modifying the CHT core
- Quick to integrate because of the existing infrastructure and knowledge around CHT

Disadvantages:

- Integrates into CHT (more prone to error chaining)
- Gamification is not available out of the box
- CHT was not especially designed for m-learning
- Content must be created using XLSForms, which requires special knowledge and is cumbersome to use
- Can be confusing for CHWs because learning tasks appear in the same column as other tasks

4.3.3 Custom implementation

Due to time constraints and the good availability of alternatives, this solution was deemed inferior to the others before a complete evaluation.

4.3.4 Explanation of the chosen solution

Based on the pros and cons mentioned above, favoring integration into CHT would be the most straightforward. However, certain important factors led to the decision against an integration into CHT. The biggest drawbacks were that content must be created in the form of XLSForms which are not especially designed for m-learning. Hence it is almost impossible for anyone without specific knowledge about XLSForms and CHT to create learning material easily. This easy creation of learning material is an important requirement that should be achieved, so that new content can be created without too much effort or technical know-how.

The second important point is the necessary modification of the CHT core to implement the required features like gamification. Further modification would also be necessary for making CHT clearer e.g., that screening- and learning tasks can be divided into different header columns. This requires forking the application on the technical side and is as of now not planned, as it adds much more complexity. Hence implementing the needed improvements mentioned above was determined to be out of scope.

Therefore, the decision was made to pursue integration with OppiaMobile. Some disadvantages like longer and more complicated setup remain present.

4.4 OppiaMobile

4.4.1 Integration of OppiaMobile into ComBaCaL

OppiaMobile is integrated into the ComBaCaL project in the context of to education and further training. The goal is not to replace the physical training on site, but rather to complement it. This is currently done by teaching the CHWs about diabetes in person and then allowing them to deepen, expand and test this knowledge independently using the OppiaMobile diabetes course. OppiaMobile opens up the possibility of providing CHWs with remote training opportunities. Through the notification system in the application itself, CHWs are notified when new learning material is available and can work on it independently. This enables them to achieve even better learning results in the future and to focus more on practical application rather than theory within the physical training. OppiaMobile is also used within the framework of ComBaCaL to easily check what has been learned in the form of quizzes and thus identify any knowledge gaps.

Finally, OppiaMobile exists in parallel and largely independent of CHT. CHT covers the areas of diagnosis and treatment and OppiaMobile provides the CHWs with the possibility for e-learning.

4.4.2 ComBaCaL infrastructure overview

The following diagram shows an overview of how the OppiaMobile infrastructure looks like with ComBaCaL.

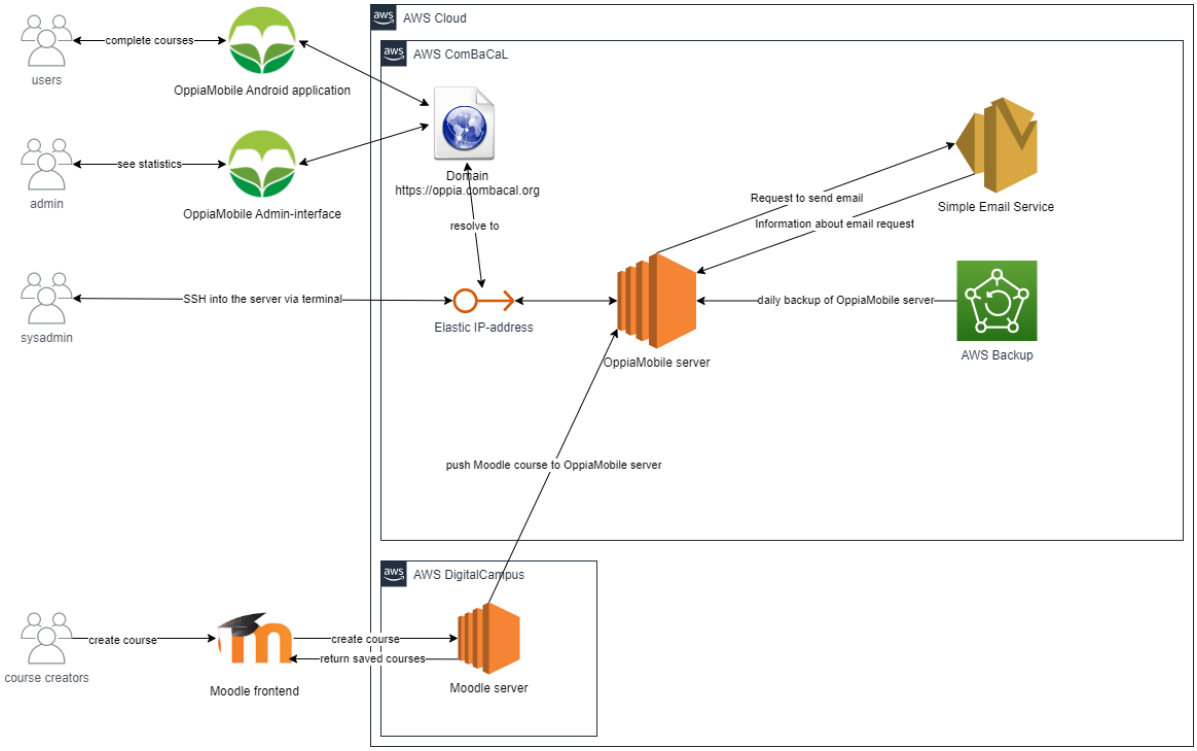

Figure 2 ComBaCaL infrastructure diagram

As seen in Figure 2, the OppiaMobile server is an amazon EC2 instance, a so-called virtual machine that is running Linux Ubuntu on which runs an Apache2 web server. On this web server a database and Django, a python based web server, is running, providing all the needed features as API endpoints.

The OppiaMobile server is connected with the Amazon Simple Email Service (SES) which allows cheap and straightforward email integration. This is needed for various user flows e.g., when a user clicks on "forgot password" in the application, the OppiaMobile server will send a request with a password reset link to SES which then sends this link to the respective email address of the account, linked to the user. SES thereafter informs the OppiaMobile server that the email has been successfully delivered.

For disaster management, AWS Backup ensures that a snapshot of the whole OppiaMobile server is created daily and saved with a retention time of two weeks. In case of errors or failure of the OppiaMobile server, this allows a quick restore to a backup with a maximum data loss limited to one day.

The OppiaMobile server itself has an IP-address that can change from time-to-time e.g., when the virtual machine is restarted. Therefore, a static Elastic IP-address is needed, since this IP-address always stays

the same and adapts automatically to the changing address of the virtual machine. This address serves as the entry point to the OppiaMobile server. Since an IP-address is difficult to remember for humans and does not really show what can be expected when accessing it, there is a subdomain of https://combacal.org pointing to the Elastic IP-address. Namely, this is https://oppia.combacal.org which is easy to remember and demonstrates what can be expected when accessing. The domain gets resolved to the Elastic IP-address as seen in Figure 2.

The Moodle server is currently hosted by Digital Campus and uploads the created course via the installed Moodle block to the OppiaMobile server using the Django admin credentials of the OppiaMobile server. The Moodle hosting can be changed to a custom hosting from ComBaCaL in the future if this is needed or desired. Currently, the Moodle from Digital Campus is more than sufficient for our needs and thanks to the separation of the Moodle and our server any security concerns can be reduced.

The user, in our case CHWs, accesses the learning content with the OppiaMobile application that can be downloaded free of charge from the Google Play Store. The setup of the application is very easy because only the URL of the OppiaMobile server must be entered in the settings and then an account can be created.

The admin can use the admin dashboard by accessing https://oppia.combacal.org in any browser and log in with the admin credentials.

The system admin can connect to the OppiaMobile server directly using SSH in the terminal. This gives them the opportunity to edit server settings and manage updates etc. directly on the server.

Course creators need to access https://content.oppia-mobile.org in any browser. There they can create the course and afterwards export it easily to the OppiaMobile server with the installed Moodle block.

4.4.3 OppiaMobile application

Following the OppiaMobile application and its components are described to aid understanding. The uncut screenshots of the application can be found in Appendix A.1.

Home Screen

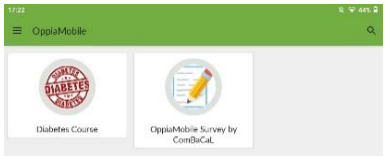

Figure 3 Home screen overview

The home screen is shown when the OppiaMobile application is opened and the user is logged in. It acts as a starting point and shows the courses available to study in this case "Diabetes Course" and "OppiaMobile Survey by ComBaCaL". Note that the number of courses and course logos/names may vary over time.

Course Overview

Figure 4 Course overview

The course detail is shown in Figure 4. Note that a module is in this example the dropdown menu "Diabetes". Further a page is e.g. "What is Diabetes?". This is the hierarchy in which courses are built. Courses consist of modules which themselves consist of pages as the lowest level element. By tapping on any, the user is taken to the respective page and can start studying.

Page Overview

Figure 5 Page Overview

A specific page is depicted in Figure 5. This is the content that can now be studied. It can consist of text, video, pictures and audio. Navigating to the next page from here can be done via two ways: Either one can swipe left to go to the next page or right to go to the previous one, or the back arrow in the top left corner can be pressed and one gets taken to the course overview page where the next page can be manually selected.

Quizzes

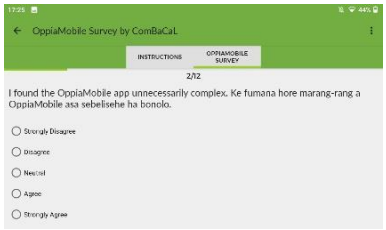

Figure 6 Quiz overview

To test the knowledge or to gain feedback on various topics, OppiaMobile offers the option to use quizzes. In Figure 6 a quiz with multiple choice questions is shown where only one answer may be selected. There are many other options for quiz questions available through Moodle.

Scorecard

Figure 7 Scorecard overview

On the scorecard page, shown in Figure 7, one can see how many activities per course have already been completed. A page or quiz count as one activity. After all activities are completed, a badge is awarded.

Badges

Figure 8 Badge overview

Badges are an additional gamification element next to the points integrated in OppiaMobile. Badges are earned after working and completing a whole course. Custom badges can be created by the course author and are rewarded if the criteria is fulfilled.

Leaderboard

Figure 9 Leaderboard overview

The leaderboard is yet another gamification element which has the intent to motivate learners by comparing their learning with others. The leaderboard is based on each one's personal points that were collected during the usage of OppiaMobile.

5 Evaluation

OppiaMobile was tested in an experimental setting which resembles the environment in which the application will be used. The experiment took place in Lesotho and had 10 CHWs participating. All CHWs have been working for ComBaCaL before and are therefore already familiar with the organization and the CHT application they use for screening and diagnosing diabetes. During the week of the 30.05.2022-06.06.2022, the CHWs were all staying in the same place together with further members from ComBaCaL. This week was mainly used to teach the CHWs about hypertension with the associated algorithms in CHT besides getting HIV/AIDS training. Because of the environmental factors, this was also the perfect opportunity to introduce OppiaMobile.

A member from the ComBaCaL team on site provided the download and installation of the application and connected it to our custom server. On Wednesday, 01.06.2022, the CHWs received a first brief introduction to OppiaMobile as a PowerPoint presentation. Afterwards, the CHWs were asked to open the application and create an account. If the CHWs felt like it in their free time, they could already try OppiaMobile and complete the diabetes course. Saturday, 06.04.2022, time was given on site to work through the diabetes course on their own. Participants took about 70 minutes to do so. The course mainly consists of a learning part and a quiz to test the knowledge. After working through the course, the CHWs were given time to answer the feedback questions, which were found in a separate course in OppiaMobile. These feedback questions were mainly about usability and self-efficacy in connection with tablets and the application itself.

On the following Monday, 06.06.2022, the 10 CHWs were all interviewed individually during the day by students of the NUL (National University of Lesotho) in an approximately 30 minute interview on three main topics: general questions about OppiaMobile, value of eLearning / perception of about knowledge since diabetes training and problems and improvements.

The feedback and interview responses were evaluated and analyzed together with additional data which was collected during the app usage of the CHWs.

In the following sections, more details about the course on OppiaMobile, results from feedback questions and interviews are presented.

5.1 Structure and components of the field experiment

5.1.1 Course on diabetes

As part of introducing OppiaMobile, a first course was developed within ComBaCaL, which was published on OppiaMobile. The team for the creation of this course comes from the Swiss TPH, the University of Basel and the IMRG. The goal of the course was to deepen and repeat the already acquired knowledge from the last physical training session about diabetes to the CHWs. This resulted in a diabetes refresher course, comprised of the following five topics: Introduction to diabetes,

Complications of diabetes, Screening, Diabetes diagnosis and Lifestyle counseling. The content consists mostly of text, pictures and a video on how to use a blood glucose meter. During the creation of the course material, special attention was given to the comprehensibility and cultural appropriateness. This resulted in often short but precise texts that are understandable by a layperson. At the end of the diabetes course, the quiz took place. This quiz consists out of 15 single-/multiple-choice questions and some true/false questions. The full quiz questions can be found in Appendix A.2. The questions revolve around the content of the course and aim to test the knowledge of the CHW. This gives the CHW immediate feedback on their personal state of knowledge about diabetes and might be an indication of what can be further improved. For the course creators, this quiz gives valuable information and some conclusion about what needs to be taught better or again in the future. Further ideas can be derived on what went well or badly. The diabetes course can be completed as many times as a CHW wishes, however at the moment the quiz can only be taken once, since this makes it easier to gather data about the state of knowledge after working through the course one time.

5.1.2 Feedback Questions

After completing the diabetes course, CHWs were asked to complete the feedback course. This consists out of 43 questions and is available in both English and Sesotho. All feedback questions can be found in Appendix A.3. The questions are divided into the four major topics: Perceived Ease of Use, Anxiety, Computer Self-Efficacy, and Feature Deep Dive. The first three topics and respective questions are from the survey framework of the article "Computer Anxiety in E-Learning: The Effect of Computer Self-Efficacy" (Saadé & Kira, 2009). The article discusses that many people, even those from the younger generation which should generally be more familiar with technology, have some computer-related phobia (Saadé & Kira, 2009). In their study, they have researched the effects of computer self-efficacy and computer anxiety on the use of computer-based tasks (Saadé & Kira, 2009).

The last topic of the questionnaire is about the "Feature Deep Dive" where the CHWs get asked questions about specific features of the OppiaMobile application.

5.1.3 Interview

Unfortunately, the results of the interviews could not be included in the final work. This is because the deadline for transcription and translation into English (10 days) was not met by the National University of Lesotho, and by 15.07.2022, still no results were available. Despite several attempts to draw attention to it. It is nevertheless mentioned for the sake of completeness. The interview questions can be found in Appendix A.4.

On Monday, the 6th of June 2022, the last survey on OppiaMobile was done as a one-to-one interview. The interviewer was a student from the NUL which conducted the interview in Sesotho. An audio recording of the interviews was made which later should be transcribed and translated to English by students of the NUL.

The interview was based around three major topics: OppiaMobile in general, Value of eLearning and perception about knowledge since the diabetes training and problems and improvements.

The main purpose of the interview is to gather more data to underline the assumptions made based on the course on diabetes, feedback questions and OppiaMobile usage data. Further, it offers yet another way of collecting data in the form of a face-to-face session in the CHWs native language, which gives them the opportunity to express themselves more easily and provide deeper insights.

5.2 Results

This chapter contains a description and evaluation of the data collected from the Quiz about diabetes, feedback questions and OppiaMobile usage data. Further in chapter 5.2.4 the aggregated results are analyzed. Following the data is briefly described with the help of some basic statistical measures such as mean, median and standard deviation. It is important to note that all of this is of no statistical significance as the size of the sample is only 10. Nevertheless, the results provide insights regarding the research questions posed.

5.2.1 Quiz about Diabetes

The quiz was completed after taking the diabetes course. The quiz consists out of 15 questions with the maximum achievable score being 15. The average score is 12.7 or 84% right answers with a median of 13.2 or 88% and a standard deviation of 1.6 points. The median and standard deviation are as expected and show that the results are rather closely together with no significant outliers, which in this case would have been CHWs which performed poorly.

As seen in Figure 10, there clearly exist questions that have a significantly higher error rate than others. These are questions 1, 2, 8 and 11. Question 1 and 8 have only been answered correct by half of the CHWs.

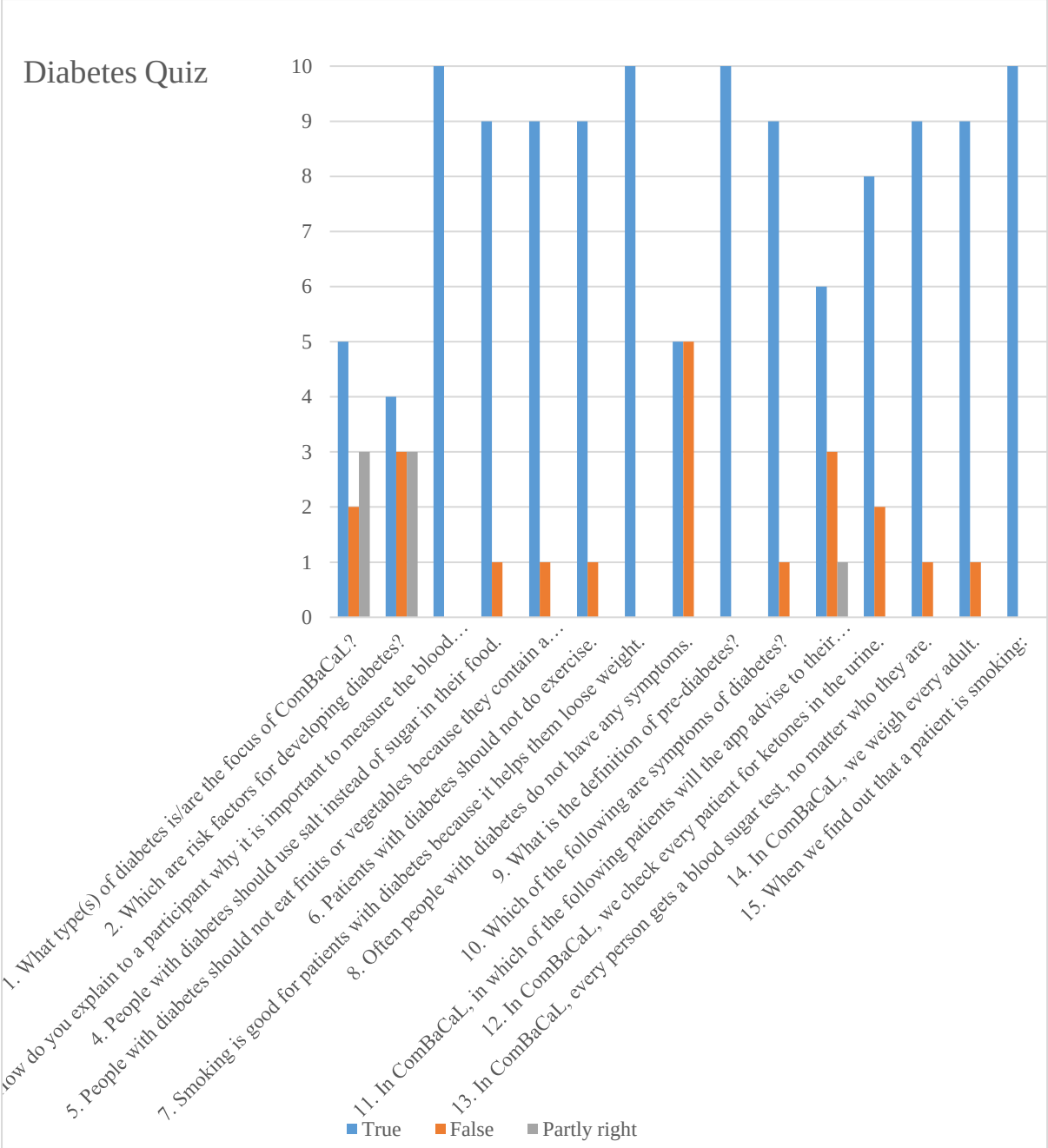

Figure 10 Diabetes quiz score by question

When looking at the user scores in Figure 11, they can be divided into three groups. The users with the UserId 8-12 are between 13.5 and 14.5 points. Users 13, 16 and 17 are between 11.7 and 12.7 points, while users 14 and 15 are between 10 and 10.4 points. No user scored below 75% of the points achievable.

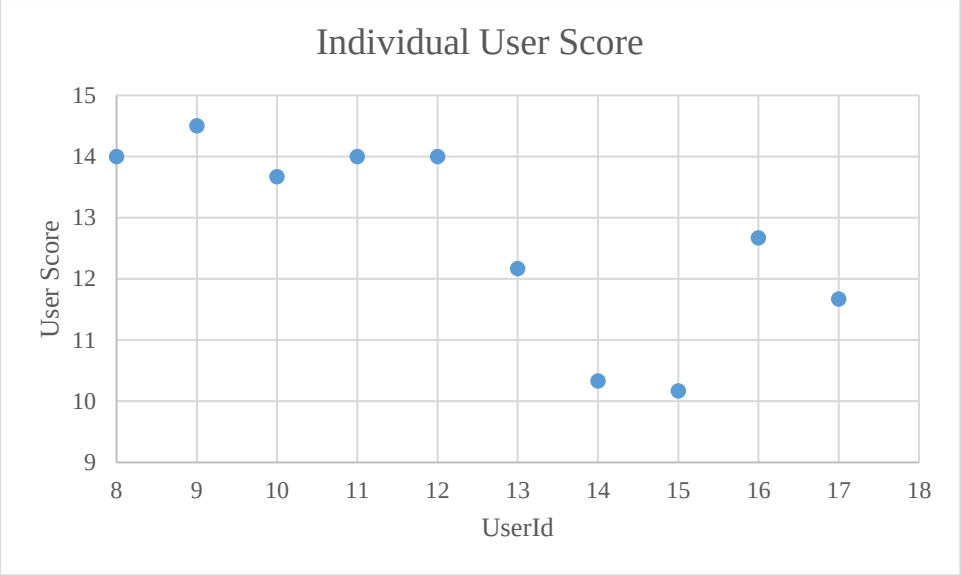

Figure 11 Individual user score in diabetes quiz

The average time spent on the diabetes course is 77 minutes, as seen in Figure 12. This includes working through the entire course with its modules and completing the quiz. In general, this is higher than expected, as course authors reckoned with around 45 minutes initially. Further, the standard deviation is quite high at 30 minutes. This explains the vast differences in the time needed to complete the diabetes course with a minimum of 39 minutes and a maximum of 143 minutes. As seen in Figure 13, there is no correlation between time spent on the diabetes course and quiz score.

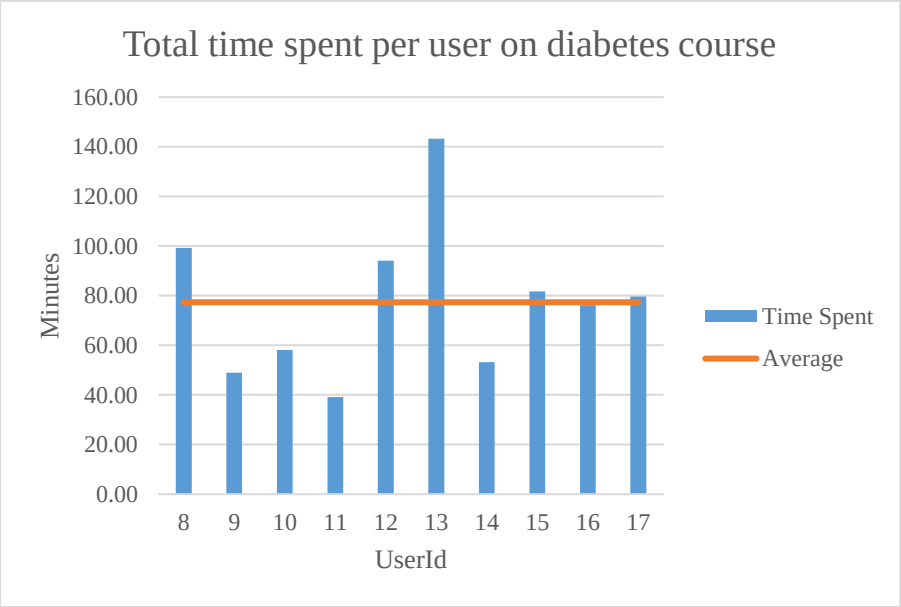

Figure 12 Total time spent per user on diabetes course

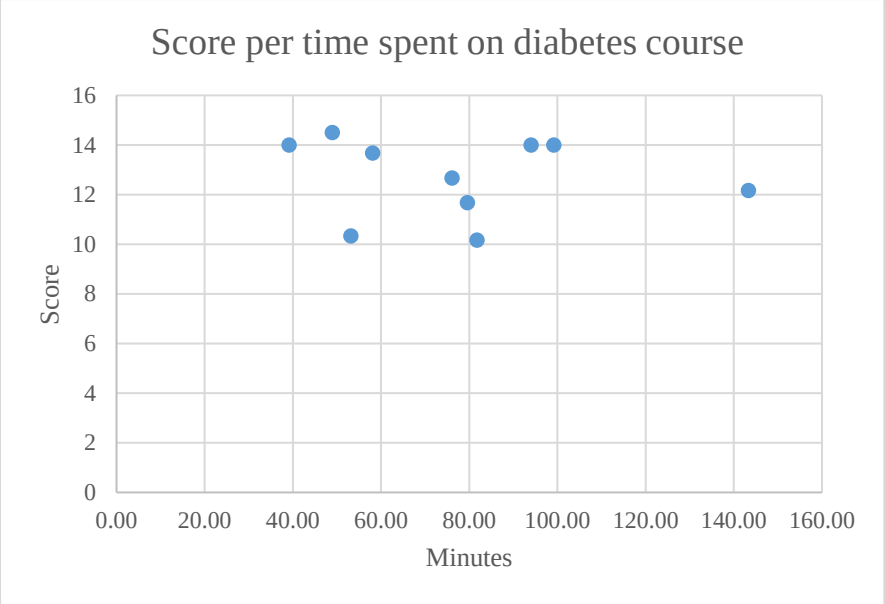

Figure 13 Score per time spent on diabetes course

One CHW spent over 140 minutes on the diabetes course and only achieved 12 points in the quiz afterwards.

5.2.2 Feedback Questions

The OppiaMobile Feedback questions were asked after the full completion of the diabetes course. The questionnaire is built around the four major topics "Perceived Ease of Use", "Anxiety", "Computer Self-Efficacy" and "Feature Deep Dive"

Perceived Ease of Use	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I think that learning to navigate the online course components will be easy for me.	0	0	0	6	4
I think that I will find it easy to get the online course components to do what I want them to do.	0	0	1	8	1
I think that it would be easy for me to become skillful at using the online course components.	0	0	0	8	2
I think that I will find the online course easy to use.	0	0	1	7	2

Table 1 Perceived Ease of Use

In general, it can be said that the CHW found the course components easy to use. Further, they are also very confident that the course components do what they want to achieve.

Anxiety	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I feel apprehensive about using mobile devices.	4	3	2	1	0
It scares me to think that I could cause the mobile device to destroy a large amount of information by hitting the wrong key.	3	3	0	4	0
I hesitate to use a mobile device for fear of making mistakes I cannot correct.	4	1	1	4	0
Mobile devices are somewhat intimidating to me.	5	4	0	1	0

Table 2 Anxiety

Most of the CHWs do not feel apprehensive about using mobile devices. However, four CHWs said that they are scared to destroy large amounts of data by pressing the wrong key. The same four CHWs also said that they hesitate to use a mobile device for the fear of making mistakes they cannot correct. Here it is not clear if they have this fear because the systems does not let them correct the mistakes or if they do not feel capable of correcting the mistakes on their own even if the system lets them. One CHW even said that mobile devices are intimidating to them. A bit over a third of the 10 CHWs have some anxiety considering the use of mobile devices.

Computer Self-Efficacy	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I could complete the required tasks using the learning tools, if there was no one around to tell me what to do.	0	0	0	6	4
I could complete the required tasks using the learning tools, if I had never used a 'learning tool' like it before.	0	2	1	5	2
I could complete the required tasks using the learning tools, if I had only the 'learning tool' manuals for reference	0	4	1	4	1
I could complete the required tasks using the learning tools, if I had seen someone else using it before trying it myself.	1	1	0	7	1
I could complete the required tasks using the learning tools, if I could call someone for help if I got stuck.	3	1	0	6	0
I could complete the required tasks using the learning tools, if someone else had helped me get started.	2	1	1	5	1
I could complete the required tasks using the learning tools, if I had a lot of time to complete the task for which the 'learning tool' was provided.	0	1	0	9	0
I could complete the required tasks using the learning tools, if I had just the built-in help facility for assistance.	1	6	0	3	0

Computer Self-Efficacy	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I could complete the required tasks using the learning tools, if someone showed me how to do it first.	1	2	0	6	1
I could complete the required tasks using the learning tools, if I had used similar 'learning tool' like this one before to do the task.	1	2	2	5	0
I think the OppiaMobile app was easy to use.	0	0	0	5	5
I think I would need the assistance of a knowledgeable person to use the OppiaMobile app.	2	2	1	4	1
I thought the various functions of the OppiaMobile app were well integrated.	0	0	0	6	4
I think the OppiaMobile app is too inconsistent.	1	6	2	1	0
I believe that most people would learn to deal with the OppiaMobile app very quickly.	0	0	0	6	4
I found the OppiaMobile app very cumbersome to use.	2	8	0	0	0
I felt very safe using the OppiaMobile app.	0	0	1	7	2
I had to learn many things before I could work with the OppiaMobile app.	1	2	2	4	1
I liked the point system in the OppiaMobile app it motivates me.	0	0	0	6	4
I think OppiaMobile supports my educational progress.	0	0	0	5	5

Table 3 Computer Self-Efficacy

As seen in Table 3, CHWs think OppiaMobile supports their educational progress. The answers regarding the assistance in using the app are very diverse. They show that there are many different desired types of assistance to be able to deal with the application. Overall, the CHWs thought OppiaMobile was easy to use, however many still said they would require assistance of a knowledgeable person in order to use OppiaMobile.

All CHWs agreed on that the various functions of the application are integrated well, and the application does not feel cumbersome to use and therefore offers a good user experience. Further, the point system was well received and acts as a motivation to CHWs.

Feature deep dive	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
The course was the right length.	0	0	1	6	3
Which form (reading text, watching video, looking at pictures, listening to audio) of learning content do you like the most?	Video 8	Text 2	Picture 0		
I like the quizzes at the end of the course.	0	0	0	6	4
The quizzes give me a good understanding about if I understand the topic.	0	0	0	5	5
I feel like the quizzes are unnecessary.	2	8	0	0	0
The quizzes are too hard.	2	4	3	0	0
I like the point system of OppiaMobile.	0	0	0	7	3

Feature deep dive	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I like the badge system of OppiaMobile.	0	0	1	8	1
Collecting points and badges motivates me.	0	0	1	8	1
I like to compare myself with other on the public leaderboard.	0	0	0	7	3
A public leaderboard is embarrassing me.	2	7	0	1	0
Comparing myself with others motivates me.	0	1	0	5	4

Table 4 Feature deep dive

As seen in Table 4, video content is by far the most liked category with 8 votes. This is remarkable because there was only one short video in the diabetes course. The quiz at the end of the course was liked and fulfilled its purpose of giving the CHWs a good understanding if they understood a topic. The gamification in the form of points and badges was well received and liked by the CHWs. The public leaderboard and the opportunity to compare one's performance with others was liked, however one CHW answered he feels embarrassed by a public leaderboard.

5.2.3 OppiaMobile usage data

OppiaMobile offers some analytical data ready to download on the admin dashboard. One of this metrics is the average time spent per user on a given day on OppiaMobile. It is clearly visible in Figure 14 that the diabetes course and the feedback questions were completed by most of the users on the 02.06.2022, 03.06.2022 and on 07.06.2022. This is also when the introduction to OppiaMobile took place. The two smaller peaks after a longer break on the 12.06.2022 and 13.06.2022 result from a few CHWs which still had to fill out the feedback questions on these days. It is clear that the CHWs did the job they were given, which is to work through the course. However, the data indicates the CHWs did not use the application actively after completing the course. Thus, the goal of continuous learning has only been half achieved so far. OppiaMobile is intended to be a place for CHWs to come back to again and again with the intention to improve and refresh their knowledge. It is not meant to be a one-time affair that ends after the completion of a course.

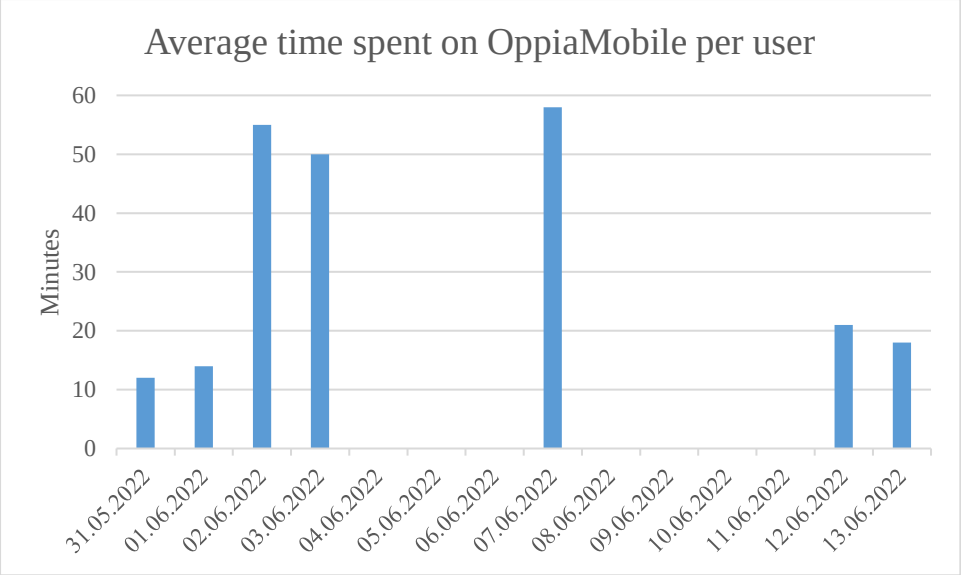

Figure 14 Average time spent on OppiaMobile per user

5.2.4 Analysis of aggregated results

The high score in the diabetes quiz is a sign that the CHWs had no big problems with the OppiaMobile application, and the diabetes course was informative regarding providing the right answers for the following quiz. However, with the lack of comparability and measures, it is impossible to say if the result of the quiz would have been different without the diabetes course preceding. This could well be the case. Further, there are other possibilities for this good result, such as the quiz being too easy or the gained experience from the previously held physical training and daily work with diabetes within the project of ComBaCaL. When looking at the diabetes quiz results in depth, the results show that both questions 1 and 8 were answered correctly by only half of the CHWs. Considering question 1, this is most likely because of the question being multiple choice and therefore harder per se than single choice. It is surprising that this question was not answered so well, since it is a question of principle. One would think that CHWs would know which types of diabetes are the focus of ComBaCaL. Most CHWs knew that type 2 diabetes is a focus, however some forgot that pre-diabetes is also focused. Interesting is the fact that two CHWs with a low total score (in the lower third) gave Type 1 and gestational diabetes as an answer. This, in combination with the low score compared to the total score, is an indication that these CHWs may need another refresher and help with diabetes in ComBaCaL. It appears that they are unaware of the types of diabetes they are diagnosing and treating within ComBaCaL. The user who answered that Type 1 is a focus of ComBaCaL, which is completely wrong, also gave the feedback that he has anxieties about clicking the wrong button in the application and therefore causing a destruction of a large amount of information. Further, the question: *"I hesitate to use a mobile device for fear of making mistakes I cannot correct."* was also answered with *"agree"* which is another indication of a general anxiety considering mobile devices. This anxiety also could have led to the rather short time spent conducting the course for this user with only 53 minutes, whereas the average time-spent was 77

minutes. In contrast, the user who had the highest score gave *"strongly disagree"* as an answer to all the questions, considering anxiety. This might be an indication that people with less anxiety feel more comfortable and therefore will perform better overall than their colleagues with anxiety regarding the use of mobile devices. Further the question is whether CHWs with anxiety have postponed working on the course because of it. When looking at the data, there is no correlation between anxiety and the time of the course taken. However, this could also be because of the short time window in which the introduction was held and the request to complete the course was made. The presence of anxiety is not that surprising when one considers that many CHWs had no or very little experience with mobile devices in the past before they were part of ComBaCaL. Further, with the use of a new application, namely OppiaMobile, there arise certain unfamiliarity's which could affirm this anxiety. Despite this existing anxiety in certain CHWs, it is gratifying to see that they completed the diabetes course and associated quiz so well. This may indicate that although there are still uncertainties and anxiety with the use of mobile devices, these do not have a significant negative impact on the use of OppiaMobile and the learning outcome. To overcome this anxiety, it is important to encourage CHWs to spend a lot of time with the application and mobile device to build trust. They will get used to it and realize that even a wrong button press within OppiaMobile will not destroy a lot of data, nor will mistakes happen they cannot correct.

In relation to diabetes quiz question 1, it is very interesting to see that while several CHWs did not recognize that pre-diabetes is a focus of ComBaCaL, they knew the definition of pre-diabetes in question 10, which was answered correctly by all CHWs. So, it could be a case of a careless mistake in question 1 or maybe the CHWs were not aware that several answers are possible and were confused by the word "focus" which may have showed only one answer to them.

Question 8 was the second question which only half of the participants got right. This result is also surprising because it is a general question. In this case, it seems reasonable to assume that the CHW overread the "not" and read the question as "Often people with diabetes do have symptoms." This would then be only half correct since many people have diabetes even without symptoms. Such questions are interesting because ComBaCaL is highly interested in CHWs that can read carefully. Carefulness is very important in diagnosis and treatment, as even small carelessness can have a big impact on the diagnosis of diabetes.

6 Discussion

This chapter discusses the results regarding the related work, problem scenarios, and research questions of this thesis. It is built around different chapters, which go from general to specific.

6.1 E-Learning requirements

One of the most important requirements, the offline first approach that the application does not need a constant internet connection was met. This is one of the technical challenges stated by Klímová (2018). After a one-time download of a course, it can be consumed completely offline at any time. What does not work during this time are the online features like the leaderboard or upload of statistics to the server which, however, do not affect the usability to the negative.

Considering the requirement of energy efficiency mainly to prevent battery drain because of the sometimes limited availability of electricity, there were no complaints so far. The battery usage of OppiaMobile seems normal and has therefore not been measured explicitly. Further, it can be concluded that this was expected due to the offline first approach and nonperformance intensive tasks.

M-learning has two sides to it with the costs decreasing by reducing the need of classrooms and teachers but on the other hand the costs increase with the need of course creators, devices and an m-learning solution (Crescente & Lee, 2011). To reduce costs inside ComBaCaL, it is crucial that the course can be created without programming knowledge and that already existing learning material can be reused easily. This has been achieved. The whole content can be created in Moodle which is UI based and no code is required. Only certain elements, e.g., a title could be further styled with some HTML code, but this is never required and mostly fulfills a cosmetic purpose. Further reusability of existing content is given and does not require much extra work if it already is in a digital form. Videos, images and text can be easily imported into Moodle and therefore used in a course. In the best case if a Moodle course already exists it could be directly imported into the application. In ComBaCaL, most of the already existing content is in the form of text documents or presentations from which the text and images can easily be copied to Moodle and afterwards used in a course. This reduces time and therefore costs for the whole ComBaCaL project.

Often when m-learning is implemented in a country with the users not being so familiar with mobile devices usage of a device and its software can be a problem (Mohammad et al., 2012). This is the case in Lesotho, as many of the CHWs have not frequently used a mobile device before ComBaCaL. Therefore, the application is simple and self-explanatory and usable by a user with little mobile device experience. The additional notifications which appear, e.g., when a new course is available, are both pleasant and useful and help dealing with the application. The only thing that seems unclear based on our experience out of the first trial is the status of a course. It was not clear to several CHWs during the trial whether they had now completed the course. A practical example of this is that several CHWs

thought they had completed the OppiaMobile Survey course, although this was not the case. This is even though indicators such as green check marks and progress bars are available for individual activities and for the entire course. A more explicit presentation, hints and notifications in case of an incomplete course status would certainly help with this problem.

The requirement that feedback must be in the loop is fulfilled. OppiaMobile offers a great opportunity with the quiz feature to give users a chance to test their knowledge. After a quiz, immediate feedback is given to the user and therefore improvements in the future can be made due to the awareness of what was right and wrong in a quiz. A different aspect of feedback is also fulfilled in how the users can give general feedback on courses, OppiaMobile, etc. with special feedback blocks incorporated into OppiaMobile. This is very important considering the future development of OppiaMobile inside ComBaCaL and was also a very liked feature by the CHWs. It helps to ensure that the user is in the loop proposing and deciding which feature he would benefit most of to maximize his personal learning efficacy and efficiency.

There is the possibility of collecting special badges after the successful completion of a course. Furthermore, as points are awarded for each course and activity, this total score can be viewed publicly on the leaderboard by all other users. This creates a small competition among the users who have collected the most points and is therefore at the top of the leaderboard. The pleasant side effect is an increased motivation. The analysis of the data has shown that the CHWs feel motivated by this gamification and appreciate the opportunity to measure and compare themselves to others. However, one user has answered that he feels embarrassed by a public leaderboard, there should therefore probably be the option to opt-out of the public leaderboard if this feature is not desired. Concluding it can be said the requirement for gamification has been met in a first stage, however there is room for improvement. With the goal of continuous learning in mind, a gamification element that rewards a frequent usage of OppiaMobile would probably be beneficial for its achievement. This could be as a badge one receives after using the application, e.g., three times a week.

M-Learning might lead to isolation, separation or to a feeling-out-of-the-loop because of the lack of physical engagement with other learners (Sarrab, 2012). This problem is not fully addressed yet inside OppiaMobile since there is no space where the learners can interact with each other. This could, however, be achieved in the future by providing, e.g. forum inside the application where CHWs can pose questions and discuss with each other over the learning topics. Still this needs further research and especially feedback from the CHWs about their wishes regarding a social feature.

6.2 Integration into ComBaCaL

Integrating OppiaMobile into ComBaCaL worked very well in general, as seen in the overall very positive feedback received from the CHWs. One user said he likes OppiaMobile a lot because of the reduction of paperwork due to the digital learning material.

There are some interesting answers in the feedback results regarding whether a task, e.g. working through the diabetes course, can be completed successfully with or without assistance. All CHWs indicated they can complete the task with no one telling them what to do. This also directly explains that all CHWs found the application easy-to-use if we assume that successfully completing it on their own shows ease of use. It is very interesting to see that many CHWs answered with disagreement to whether they can complete the task with an assistance. It is therefore worth taking a closer look at this. 4 out of 10 CHWs stated they could not complete the task if they could ask someone for help if they got stuck. However, all of them stated they could do the task completely on their own. This is strange, since one would not think that an expert providing help would be counterproductive. It cannot be assumed that this question was misunderstood and therefore the answers were wrong. This is because the question was asked in Sesotho and similar observations can also be made with the following questions (see Table 3), that help is sometimes perceived as counterproductive and not goal oriented. This result is unexpected and yet it can be justified with the literature. Learning by doing refers to learning by direct action, as opposed to learning from others by copying or following instructions (Reese, 2011). It was shown that learning by doing raised self-efficacy much more than lecture-based learning (Grez & Lindt, 2013). Considering this research, it makes sense that, with the learning by doing method, CHWs feel much more confident that they can fulfill the required task with no external help.

When looking at the feedback answers about anxiety, it appears that half of the CHWs have anxieties about pressing the wrong key and destroying data or making mistakes they cannot correct. With the experience inside ComBaCaL regarding this topic, this is most likely due to the inexperience with mobile devices, and the CHWs therefore can't estimate that they can't break a lot of things by pressing a wrong button. Nevertheless, it is very important in the future to observe this anxiety closely as it might lower the learning efficiency. It is also expected that with the increasing use of OppiaMobile, the fear of doing something wrong will decrease due to the familiarization effect. Further, as mentioned by Mohammad et al. (2012) localization should be incorporated into the application to achieve optimal results. The translation of OppiaMobile into Sesotho could be a way to help reduce the barrier to entry and to create a place of familiarity where the CHWs need not to be afraid to press a wrong button because of language barriers. Also, this would make it easier for the CHWs to learn about all the features OppiaMobile has to offer.

M-learning supplements physical learning such as face-to-face with enhancing retention and facilitation of knowledge (Klímová, 2018). This is reflected in the good average of the quiz score and is also confirmed by the learners themselves. All CHWs agree OppiaMobile supports their educational progress. This is one of the most important goals of OppiaMobile in connection with ComBaCaL and it is gratifying to see that the CHWs can benefit. It shows that it is worthwhile to further develop m-learning and especially OppiaMobile and to put a lot of emphasis on it to support the CHWs even better in acquiring and refreshing their knowledge. We show that in community-based health care; it is very

worthwhile to use resources to give CHWs a learning opportunity away from physical training. However, further research is needed to determine which split between physical learning and e-learning works best considering educational progress in the context of ComBaCaL and other community-based health care projects. It is always a tradeoff between physical learning and e-learning since resources are spare and the teachers are often also course authors for e-learning, which proposes a time constraint.

6.3 E-learning potential to improve community-based health care

In low- and middle income areas in which the community-based health care approach is used, there is the problem of a lack of in-depth training coupled with the low availability of CHWs (Perry et al., 2014). In ComBaCaL, we have used e-learning as a solution to combat these problems and ultimately provide a better service to the community. OppiaMobile leads to a reduction in costs as the CHWs work more efficiently and can concentrate on the application of the theory in practice during the physical training sessions. The in-depth performance analysis features inside OppiaMobile allow for even more personalized assistance in training, resulting in better trained CHWs. The critical onboarding process of new CHWs can be simplified as theory can be learned individually anytime and anywhere. This is possible thanks to underlying three principles of m-learning, namely mobility of technology, mobility of learning and mobility of the learner as stated by Kumar Basak et al. (2018) and shown in chapter 2.5. This was also underlined by the positive feedback from many different stakeholders, such as CHWs and people from the Swiss TPH and IMRG. It has been shown that about half of the CHWs suffer from fear of pressing the wrong button in the application. This should be investigated further and the CHWs should be asked why this fear exists and how it could best be counteracted.

OppiaMobile has proven to work very well in the short-term regarding the acquisition, refreshing and assessing of theoretical knowledge and therefore providing a suitable e-learning solution inside ComBaCaL. It has been demonstrated that m-learning is an effective method for learning new medical procedures, and practitioners' practice behavior improved as a result of using mobile devices to learn (Schopf & Flytkjær, 2012; Sena et al., 2013). It is likely that this is also true in the context of ComBaCaL, nevertheless this has not been proven and should be the subject of future research on whether and how the performance of CHWs improves after using OppiaMobile.

7 Conclusion

NCDs have risen sharply around the world in recent years, evolving into a global human crisis (WHO & Organization, 2005). Many studies have shown a positive association between NCDs and low income, low socioeconomic status or low educational status (Niessen et al., 2018). The low number of available physicians in these countries calls for novel approaches. The community-based health care approach is based on lay persons to provide primary health care for diseases (Perry et al., 2014). The lay persons often receive only short and concise training and are then sent into the field (Perry et al., 2014). The lack of repetition and thorough training is also present in ComBaCaL and therefore requires the use of an e-learning solution to address this problem.

Based on research and discussions with stakeholders inside ComBaCaL, problem scenarios considering e-learning were formed and requirements for the e-learning solution have been derived. The requirements showed important points like the solution must be easy to use for users with little mobile device experience, content for e-learning should be creatable without programming knowledge and there must be space for feedback inside the solution. Based on these requirements, different e-learning solutions have then been evaluated. The decision was made to go with OppiaMobile, which is an open-source project from Digital Campus. OppiaMobile was implemented and integrated into the ComBaCaL project. The application was tested over the course of a week in a real world setting with 10 CHWs from ComBaCaL with an e-learning course about diabetes. The feedback was very positive among all stakeholders and the collected data shows OppiaMobile can counteract against the lack of training found in community-health projects. When integrating an e-learning solution within a community-healthcare project, it is very important to tightly couple it with the physical learning. E-learning is by no means a replacement for physical learning and should be seen as an additional tool which can be beneficial when used correctly. Hereby it is important to include the goals and visions of the entire project to embed the e-learning solution deeply into the project and achieve maximum added value for all stakeholders. In the course of this thesis, it became clear that the CHWs as the most important stakeholders have to be involved in the planning from the beginning and that the unfamiliarity with the use of mobile devices can lead to additional uncertainties that have to be considered.

7.1 Limitations

The limitations of this thesis are clearly the very low number of only 10 CHWs participating in the field experiment due to the project being in its early phase and more CHWs just onboarding in the coming months. It follows that the results are all statistically irrelevant, but they do still provide a qualitative insight into the field experiment.

The learning content in the OppiaMobile application consisted out of a course about diabetes, which was already learned about in depth in various physical training sessions before. Because of this, it

remains unclear how the learning success would have turned out if it had been a course with a completely new topic and material.

The field experiment showed that the e-learning solution works very well in the short-term. However, it remains to be seen whether this is also the case in the long-term. Furthermore, it is not clear whether the actual treatment of patients improves in any way as a result of the improved theoretical knowledge within the framework of ComBaCaL.

7.2 Future Work

It is very pleasing that the first trial was so successful. The project managers within ComBaCaL decided OppiaMobile will also be used in the future within the ComBaCaL project. Even further, the use of OppiaMobile will be expanded to enable even better continuous learning, just-in-time training and easier onboarding of new CHWs. Already after this short time since introducing OppiaMobile, it is essential to achieve the goals of ComBaCaL. With these previously mentioned ambitious goals in mind, there is also a lot of work that still needs to be done. In the following part, these tasks are divided into three groups of short-term, middle-term and long-term. Short-term covers the next 1-3 months, middle-term the next 3-6 months and long-term 6-12 months. The following tasks are not to be regarded as final and can change constantly with the further course of the entire project. Nevertheless, they are a good overview of how OppiaMobile will proceed specifically with the stand today.

7.2.1 Short-term (1-3 months)

One of the primary goals around OppiaMobile in ComBaCaL is the enablement of just-in- time learning. This means that a CHW can learn, e.g. why measuring blood sugar is important on the spot while working with a patient. This feature is built in within OppiaMobile with the use of hyperlinks to whole courses, modules or pages. The existing content from OppiaMobile has to be integrated with the use of such hyperlinks into the CHT config. This gives the CHW the ability to press the hyperlink in the form of a button while using CHT, if desired. The OppiaMobile application is then opened at the relevant point and the CHW can view the content or the explanation of the specific task again on the spot. The goal of this is to be always up to date and to give the CHWs the possibility to continuously educate themselves and to offer even better health care services to their patients. This is done by linking simple but powerful tools that they have already got to know individually, in our case the CHT and OppiaMobile applications.

The OppiaMobile server runs fine for the ten users that are using it. However, with the expansion plans within ComBaCaL, there may be a limit in the future on the server being too small to handle the bigger number of users. It is very important to notice here that most of the time the server load is at a bare minimum because no constant connection from the application to the server is needed, since the OppiaMobile application is offline first. However, spikes in server load can occur when many users, e.g., download a course simultaneously. This may lead to the server being very slow or even crashing

in the future when many users use OppiaMobile. There are two potential solutions to this from a technical standpoint: One is to upgrade the current AWS VM to a bigger and therefore more powerful one. This solution is very easy and can be done within minutes, however this comes with the downside of having a powerful VM running 24/7 when this performance is not needed most of the time, which results in drastically higher costs in the end that are unnecessary. The second solution is the setup of an auto scaling solution within AWS. This means that whenever more performance is necessary, the VM is upgraded automatically to one with more power. Then, as soon as the power is not required anymore, the VM is downsized again to its original power. This brings the advantage of only having and paying for the extra power when it is needed. Further, in the case of ComBaCaL and OppiaMobile, this seems like the logical solution because of the server utilization being very unbalanced and volatile.

As we have seen in the results, a few CHW answered they had the anxiety of pressing a wrong button and therefore deleting a lot of data or breaking the application. To help handling this anxiety better, it might be helpful to create better informational material about OppiaMobile. The best way would be to do this directly inside the application as a separate course that walks through the whole application and explains every bit and piece. This hopefully lowers the burden of working with OppiaMobile and should, in the best case, encourage tinkering around with the OppiaMobile.

To fully leverage the potential of OppiaMobile, introducing more content is crucial to ensure the goal of continuous learning. CHWs should be reminded and encouraged to have a look at the OppiaMobile courses from time to time for the benefit of refreshing their knowledge and thus providing faster and better services to their patients which still is one of the number one goals behind the introduction of OppiaMobile in ComBaCaL. Further, all the things that a CHW with the ComBaCaL project must know should optimally be in a way inside the OppiaMobile application. When this state is reached, the application can act as a source of truth for all questions and concerns a CHW might have. As of now, a fresh course is already in the planning phase, which will deal with hypertension.

7.2.2 Medium-term (3-6 months)

In the medium-term, there is the need for an own Moodle instance. Currently, the Moodle instance hosted and provided by Digital Campus is used for ComBaCaL. Even though Moodle is only used for creating courses and quizzes for OppiaMobile and has therefore no direct linkage, the project is still reliable upon Digital Campus. This means they have full control over all courses and material created and uploaded onto Moodle. This brings the advantage that they can help easily if a problem occurs and ComBaCaL has no extra costs and personnel expenses that would result from hosting an own Moodle instance. There is no formal contract between ComBaCaL and Digital Campus considering the usage of the Moodle. This introduces some potential risks, where ComBaCaL could lose access to the whole content already created with nothing that could be done about this.

With this knowledge, it is inevitable in the medium-term that a separate Moodle instance will be set up and operated. This brings fewer dependencies upon external stakeholders and additionally the benefits of a configuration according to ComBaCaL's own wishes and a better user management, since this can now be administered by ComBaCaL itself. A porting of the content on the current Moodle to the new instance should be easily and quickly feasible with the help of the export functionality. For an easy setup, it is suggested using the AWS EC2 platform with the Amazon Machine Image (AMI) functionality, which makes it possible to spin up a Moodle instance with only a few clicks and very little additional configuration. This option also presents itself, as both OppiaMobile and CHT each run on AWS EC2.

The OppiaMobile dashboard offers a lot of analytical data that can be downloaded as comma-separated values (CSV) file. This includes courses, general application and quiz statistics and further structured query language (SQL) queries can be made to the underlying database of OppiaMobile to collect and aggregate even more data. With the intention that in the future, the number of CHWs within ComBaCaL will increase rapidly, this is valuable data for analysis and evaluation. For example, learning progress can be measured or it can be determined whether and where there are still general ambiguities in the diagnosis of diabetes for example, so that these can be looked at again in more detail. Furthermore, with the help of the feedback function, feedback can be obtained and analyzed quickly and easily. The data is there, but the analysis options are very limited out of the box. To get as much information as possible from the data, an analysis framework should be created. This with the goal to have a fast, efficient and in the best case automatic process to get information out of the data. To achieve this, there are many possibilities, a few of which are: customized spreadsheets with built in analysis, data science pipeline and external dashboard, the use of a software like Tableau to aggregate and analyze the different data from CSV files and direct database connection.

7.2.3 Long-term (6-12 months)

In the long-term, a discussion about the forking and therefore modification of the OppiaMobile android application must be held. This would open up the possibility of giving the application a look and feel catered to the wishes of ComBaCaL. One idea would be the forking of the current application code and therefore ensuring updates and compatibility with the features released by Digital Campus. A benefit of this is an own application in the Google Play Store that can come pre-configured out of the box after the download.

The server code of OppiaMobile could also be forked and modified to fully match all the requirements of ComBaCaL. This also does also hold pros and cons, which, due to the complexity, are not discussed here further.

OppiaMobile with its frontend and backend code is fully open source on GitHub. This gives the opportunity to contribute to the project and bring in new features and bug fixes in this way and thereby

improving the OppiaMobile for the whole community. Nonetheless it has to be clear, that these changes have to be accepted by the owner of the repository, in this case Digital Campus. Presumably, it is best to discuss with Digital Campus first, if the new features that are planned are welcomed and therefore could be potentially merged into the application.

Whether these potential upsides make up for the downsides must be discussed again when the time comes within the ComBaCaL project.

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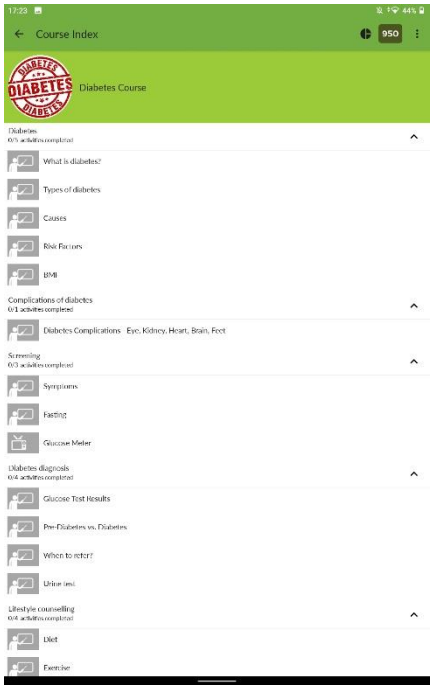
A. Appendix

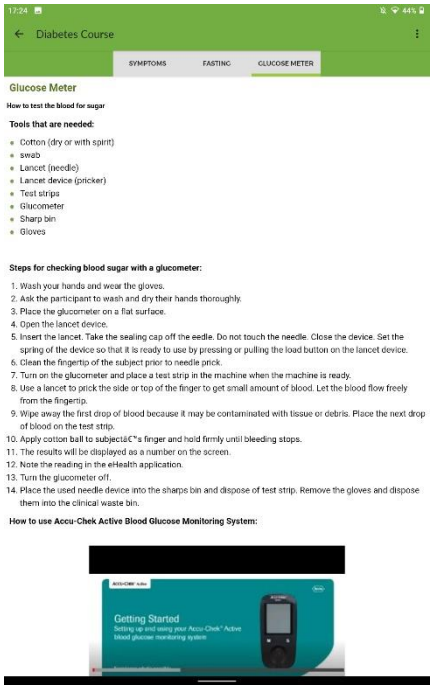
A.1 Screenshots of OppiaMobile

Home Screen

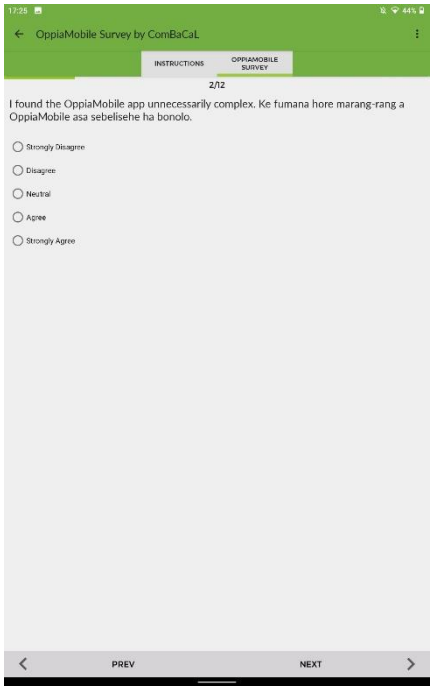
Course Overview



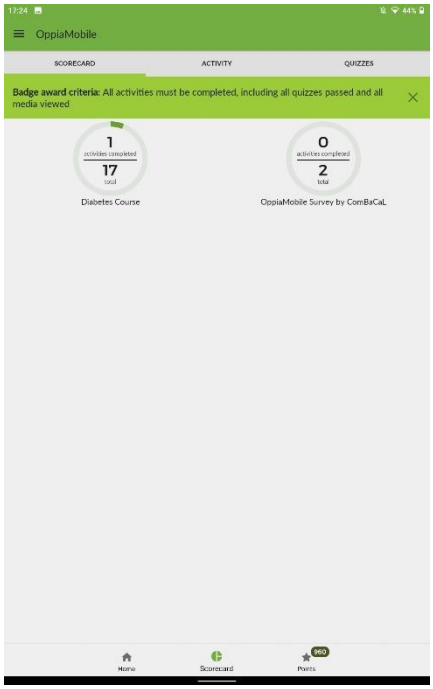
Page Overview



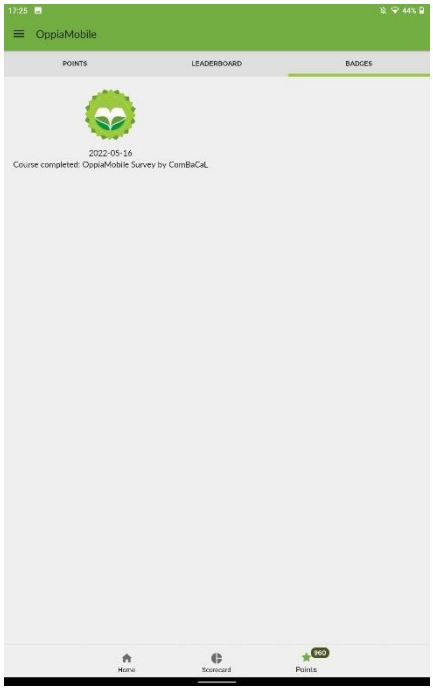
Quizzes



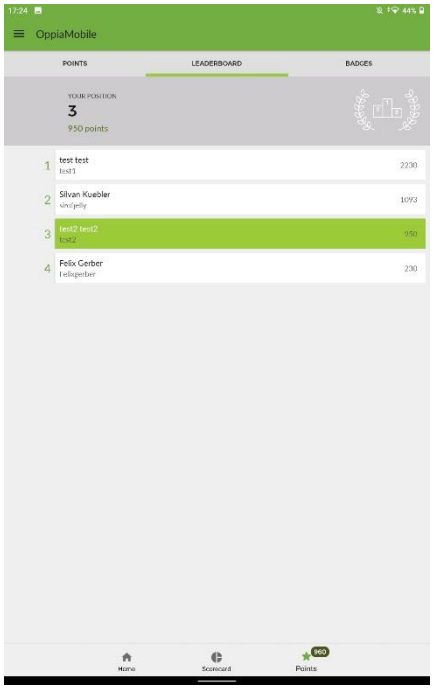
Scorecard



Badges



Leaderboard



A.2 Quiz questions

	Question and answer possibilities	**True answers**
Q1	*What type(s) of diabetes is/are the focus of ComBaCaL? (you can choose more than one answer)* Type 1 Type 2 Gestational Pre-diabetes	2 and 4
Q2	*What is not a risk factor for developing diabetes?* Lack of physical activity High salt intake Obesity Drinking a lot of sweetened beverages	2
Q3	*How do you explain a participant why it is important to measure the blood sugar?* You need to measure it, because you are paid for measuring the blood sugar. Because having a high blood sugar can be dangerous in the long term and a patient cannot feel it, therefore it has to be measured to find out The app tells you to measure it, therefore you need to do it It does not cause harm, so no problem just measuring it for fun	2

Q4	*Indicate whether the following statements are true or false:* People with diabetes should use salt instead of sugar in their food People with diabetes should not eat fruits or vegetables because they contain a lot of sugar White bread is better than brown bread for patients with diabetes Patients with diabetes should not do exercise Smoking is good for patients with diabetes because it helps them loose weight Often people with diabetes do not have any symptoms	F F F F F T
Q5	*What is the definition of pre-diabetes?* It is diabetes in people that are allergic to anti-diabetes medication It is like diabetes but worse It is diabetes in children or young people Prediabetes is when the blood sugar level is higher than it should be but not high enough to diagnose diabetes	4
Q6	*Which of the following are symptoms of diabetes? (you can choose more than one answer)* Being thirsty a lot Urinating a lot Smoking cigarettes Losing weight Coughing	Y Y N Y N
Q7	*True or False* In ComBaCaL, we check every patient for ketones in the urine In ComBaCaL, every person gets a blood sugar test, no matter who they are In ComBaCaL, we weigh every adult.	F F T
Q8	*We want to know if the person is fasting or not because:* We should not check blood sugar if they are fasting because of religious reasons We should not take blood from the body if they did not just have something to eat. Depending on what someone ate or drank, fasting blood glucose and random blood glucose measurements can be very different, and we use a different number for deciding if a person has diabetes or not. We never want to visit someone's home before breakfast.	3
Q9	*When we find out that a patient is smoking:* Tell them it is OK to keep smoking, it won't cause any problems. Tell them that is was not very smart to start smoking Teach them about the bad effects of tobacco and encourage them to stop Tell them that you will not take care of their diabetes until they stop smoking.	3
Q10	*In ComBaCaL, in which of the following patients will the app advise to their sugar to be tested (you can choose more than one answer)* BMI is 31 and Age 47 BMI 26 and Age 29 BMI 18 and Age 51 BMI 24 and Age under 39	Y Y Y N

A.3 Feedback questions

Perceived Ease of Use
I think that learning to navigate the online course components will be easy for me.
I think that I will find it easy to get the online course components to do what I want them to do.
I think that it would be easy for me to become skillful at using the online course components.
I think that I will find the online course easy to use.
Anxiety
I feel apprehensive about using mobile devices.
It scares me to think that I could cause the mobile device to destroy a large amount of information by hitting the wrong key.
I hesitate to use a mobile device for fear of making mistakes I cannot correct.
Mobile devices are somewhat intimidating to me.
Computer Self-Efficacy
I could complete the required tasks using the learning tools, …
...if there was no one around to tell me what to do.
...if I had never used a 'learning tool' like it before.
...if I had only the 'learning tool' manuals for reference
...if I had seen someone else using it before trying it myself.
...if I could call someone for help if I got stuck.
...if someone else had helped me get started.
…if I had a lot of time to complete the task for which the 'learning tool' was provided.
...if I had just the built-in help facility for assistance.
...if someone showed me how to do it first.
...if I had used similar 'learning tool' like this one before to do the task.
I think the OppiaMobile app was easy to use.
I think I would need the assistance of a knowledgeable person to use the OppiaMobile app.
I thought the various functions of the OppiaMobile app were well integrated.
I think the OppiaMobile app is too inconsistent.
I believe that most people would learn to deal with the OppiaMobile app very quickly.
I found the OppiaMobile app very cumbersome to use.
I felt very safe using the OppiaMobile app.
I had to learn many things before I could work with the OppiaMobile app.
I liked the point system in the OppiaMobile app it motivates me.
I think OppiaMobile supports my educational progress.
Feature deep dive
The course was the right length.
Which form (reading text, watching video, looking at pictures, listening to audio) of learning content do you like the most?
I like the quizzes at the end of the course.
The quizzes give me a good understanding about if I understand the topic.
I feel like the quizzes are unnecessary.

The quizzes are too hard.
I like the point system of OppiaMobile.
I like the badge system of OppiaMobile.
Collecting points and badges motivates me.
I like to compare myself with other on the public leaderboard.
A public leaderboard embarrasses me.
Comparing myself with others motivates me.
Anything else you want to tell us?

A.4 Interview questions

OppiaMobile in general
How did you feel while using the OppiaMobile application?
What do you think about the mix of physical learning (like now with hypertension training) and eLearning in OppiaMobile?
Do you feel comfortable using OppiaMobile on your own in the future? • What gives you this comfort?
What do you like most about OppiaMobile? Why?
What do you like least about OppiaMobile? Why?
Value of eLearning / perception of about knowledge since diabetes training
Do you think that your knowledge about diabetes is better now after the course? • In what aspect have you realized your knowledge gain the most? • What would help you to improve your knowledge even further?
What value do you see in learning with the OppiaMobile app for you personally? (e.g ability to learn from everywhere at anytime and anywhere, own speed, ability to refresh knowledge etc.) • Why is this aspect especially important for you? • How will this help you in your work as a CHW? (e.g feel more confident, better preparation, more knowledgeable, better response for patients etc.)
The following is a description of a scenario: Imagine yourself in a patient's home and you must measure blood pressure. You have **not** done this task for 3 months. • How do you think would a small refresher on how to measure blood pressure help you in this situation? • Would you wish to do this before you visit the patient? • How would you make sure that you do this before? (e.g. integrated in CHT)
Problems and improvements
Have you ever felt overwhelmed while using OppiaMobile? • When?

• Why?
Have you had any problem with OppiaMobile? • If any, which?
What can we improve in OppiaMobile, so it helps you to learn better?