DIRENE
Competences for the new era of user-driven digital rehabilitation

fh st.pölten

Development of a guide for educators to create mobile learning units on digital rehabilitation for working and aspiring health professionals in sub-Saharan Africa.

Master Thesis

For attainment of the academic degree of
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by
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Declaration

I declare that I have developed and written the enclosed Master Thesis completely by myself, and have not used sources or means without declaration in the text. Any thoughts from others or literal quotations are clearly marked. This work was not used in the same or in a similar version to achieve an academic grading or is being published elsewhere.

Vienna, 24.05.2022 .....

Place, Date

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Signature

Preface

I am happy that I had the opportunity to write this master thesis within such an international project as the Erasmus+ project DIRENE and that I was given the chance to implement my idea to conduct a survey in the African countries. I hope that in this way, I can bring a little more attention to the concerns and needs of health professionals in mobile learning on digital rehabilitation in sub-Saharan Africa.

Therefore, first and foremost, I want to thank all the participants who took part in this study. Without your participation in the survey, it would not have been possible to conduct this study.

Secondly, I thank my advisors FH-Prof. Dipl.- Sporting. Dr. Mario Heller and FH-Prof. Anita Kidritsch, PT M.Sc. of St. Pölten University of Applied Sciences (Austria), for their excellent and reliable support during the master thesis.

Furthermore, I want to thank Anita Kidritsch for the opportunity to participate in the presence meeting of the DIRENE project in November, which gave me a comprehensive insight into the DRIENE project. A special thanks goes to Kari-Pekka Murtonen from the Jyväskylän ammattikorkeakoulu University of Applied Sciences, who is responsible for the contact with the African partners in the DIRENE project and who forwarded my survey to his contacts.

Another big thanks goes to Claudia Barth from the ICRC, who forwarded the link to my survey to her international contacts.

Finally, I want to thank my family, my friends, and especially my partner Manuel, who always supported and motivated me during the master thesis, helped me with proofreading, and mentally supported me.

Abstract

Background: In 2013, there was a global shortage of 7.2 million qualified health professionals, which is expected to grow to 12.9 million by 2035. Especially in sub-Saharan Africa, the unmet need for rehabilitation is serious. As technology improves and digitalization increases in sub-Saharan Africa, it has become increasingly clear that using technology to train more health professionals is part of the solution to healthcare challenges. However, the needs of health professionals in sub-Saharan Africa regarding digital rehabilitation through mobile learning are still unknown.

Aim: The goal of the study is to gain insight into how mobile learning units on digital rehabilitation should be designed for health professionals in sub-Saharan Africa, with the aim to develop a digital guidebook for educators on how to create mobile learning units for health professionals on digital rehabilitation in this region.

Methods: Literature research was conducted, and based on the findings, a mixed methods questionnaire was developed and used in an online survey of an exploratory cross-sectional study to explore the needs of working and aspiring health professionals in sub-Saharan Africa regarding mobile learning on digital rehabilitation in their roles as educators and learners. Based on the survey and the literature findings, a digital guidebook for educators was developed in the form of animated learning videos with interactive elements.

Results: 13 people from five countries in sub-Saharan Africa participated in the study. 23 needs were identified, with no major differences found between the needs of learners and educators. The needs were summarized in the categories (1) Needs regarding the design of the content, (2) Technical needs, (3) Needs for educational support, (4) Needs for infrastructure, and (5) Further needs. For the digital guidebook, four interactive learning video clips were created.

Conclusion: The study and the literature research provided sufficient results to create a digital guidebook. However, because of the recognized limitations, the informative value of the results is limited. Therefore, the identified needs can be related primarily to working health professionals in English-speaking countries in sub-Saharan Africa who have at least reasonably stable access to the Internet and have already been exposed to digital services.

Kurzfassung

Hintergrund: 7,2 Millionen qualifizierte Gesundheitsfachkräfte fehlten 2013 weltweit und bis 2035 wird ein Fachkräftemangel von 12,9 Millionen erwartet. Insbesondere in Subsahara-Afrika ist der ungedeckter Bedarf an Rehabilitation groß. Zunehmende technologische Entwicklung und Digitalisierung in Subsahara-Afrika machen deutlich, dass der Einsatz digitaler Technologien in der Ausbildung von Gesundheitsfachkräften Teil der Lösung für die Herausforderungen im Gesundheitswesen ist. Die Bedürfnisse des Gesundheitspersonals in Subsahara-Afrika zu digitaler Rehabilitation durch mobiles Lernen sind indes noch unbekannt.

Ziel der Arbeit: Ziel der Studie ist es, Erkenntnisse über die Gestaltung mobiler Lerneinheiten zur digitalen Rehabilitation für Gesundheitsfachkräfte in Subsahara-Afrika zu gewinnen, um einen digitalen Leitfaden für Lehrende zu entwickeln, der darlegt, wie mobile Lerneinheiten für Gesundheitsfachkräfte in Subsahara-Afrika zur digitalen Rehabilitation gestaltet werden sollten.

Methode: Eine Literaturrecherche wurde durchgeführt und basierend auf den Ergebnissen ein Fragebogen mit gemischten Methoden entwickelt. Dieser wurde in bei einer Online-Umfrage einer explorativen Querschnittsstudie verwendet, um die Bedürfnisse berufstätiger und angehender Gesundheitsfachkräfte in Subsahara-Afrika bezüglich mobilen Lernens zur digitalen Rehabilitation in ihren Rollen als Lehrende und Lernende zu untersuchen. Auf Grundlage der Umfrage und der Literaturergebnisse wurde ein digitaler Leitfaden für Lehrende in der Form animierter Lernvideos mit interaktiven Elementen entwickelt.

Ergebnisse: 13 Personen aus fünf Ländern in Subsahara-Afrika nahmen an der Studie teil. Es wurden 23 Bedürfnisse ermittelt, wobei keine großen Unterschiede zwischen den Bedürfnissen Lernender und Lehrender festgestellt wurden. Die Bedürfnisse wurden in den Kategorien (1) Inhaltsgestaltung, (2) Technik, (3) Pädagogische Unterstützung, (4) Infrastruktur und (5) Weitere zusammengefasst. Für den digitalen Leitfaden wurden vier interaktive Lernvideos erstellt.

Schlussfolgerung: Diese Arbeit lieferte ausreichende Ergebnisse für die Erstellung des digitalen Leitfadens. Aufgrund der festgestellten Einschränkungen ist die Aussagekraft der Ergebnisse jedoch begrenzt. Daher können die ermittelten Bedürfnisse primär auf berufstätige Gesundheitsfachkräfte in englischsprachigen Ländern in Subsahara-Afrika bezogen werden, die über einen weitgehend stabilen Internetzugang verfügen und digitale Anwendungen bereits kennen.

List of Abbreviations

CHWs	Community health workers
DIRENE	Competences for the new era of user-driven digital rehabilitation
eHealth	Electronic health
eLearning	Electronic learning
GNI p.c.	Gross national income per capita
HTML	Hypertext markup language
ICTs	Information and communication technologies
JMIR	Journal of Medical Internet Research
mHealth	Mobile health
mLearning	Mobile learning
NCIB	National Center for Biotechnology Information
SD	Standard deviation
WHO	World Health Organization

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1 Introduction

In 2013, the World Health Organization (WHO) published a report that pointed to a deficit of 7.2 million qualified health professionals worldwide (Campbell et al., 2013). Most countries below the threshold of 22.8 recommended midwives, nurses, and physicians per 10,000 people are in Africa (Campbell et al., 2013). The number of physiotherapists is also very low. For 2020, the African member countries of World Physiotherapy reported only an average of 0.2 physiotherapists per 10,000 inhabitants (World Physiotherapy, 2020a). This compares to an average of 11.7 physiotherapists per 10,000 people in Europe (World Physiotherapy, 2020b).

Clearly, more health professionals need to be trained to increase the healthcare workforce in Africa. However, there are barriers to providing fast, high-quality basic and further education.

This introduction presents in detail the problem statement, the resulting research question, and the aim and objectives of the study. In the next chapter, the theoretical background is described. The research methodology and the study results are then presented, followed by a conclusion and discussion.

1.1 Problem Statement

The numbers of health professionals mentioned above show the massive shortage of skilled personnel to meet the physical rehabilitation needs of the African population. Especially in sub-Saharan Africa, the unmet need for rehabilitation is serious (Kamenov et al., 2019). To increase the healthcare workforce, new and more health professionals need to be educated. Unfortunately, the number of medical schools training health professionals to address this shortage is also insufficient (Frenk et al., 2010; World Physiotherapy, 2020a).

Considering the rising number of Internet users (International Telecommunication Union, n.d.-a) and mobile cellular subscriptions (International Telecommunication Union, n.d.-b) in sub-Saharan Africa, the idea of using technology to improve healthcare and education of health professionals in sub-Saharan Africa is an obvious one. Educators reach a larger number of students, and health professionals can provide digital rehabilitation services through the use of technology and thereby reach more patients.

A survey found that the use of technology to care for patients in Africa is already allowed in many countries. 67% of African member countries of World Physiotherapy are authorized to provide telemedicine services, which is similar to Europe at 76% (World Physiotherapy, 2020a, 2020b).

In addition, studies have shown that most students who study a health profession already own a smartphone, so access to a device is not a barrier. It was found that 94.9% of students in various health professions in Uganda own a smartphone (Olum et al., 2020). However, the authors found that only 61.2% own a computer. Another study conducted in Rwanda confirms that of the technology devices, mobile phones are the most used to search for educational content (Rusatira et al., 2016). Therefore, it is advisable to focus on the use of mobile technology as a tool when integrating technology into the education of health professionals.

Several studies have been conducted on the use and effectiveness of mobile technology for educational purposes as well as on the attitudes toward electronic learning (eLearning) and mobile health (mHealth) of health professionals in sub-Saharan Africa (Barteit et al., 2018; Barteit, Jahn, et al., 2019; Barteit, Neuhann, et al., 2019; Braun et al., 2013; Nishimwe et al., 2021; O'Donovan et al., 2015; Olum et al., 2020; Otu et al., 2016; Pimmer et al., 2013, 2014; Rusatira et al., 2016). Most of the studies that have been reviewed by O'Donovan et al. (2015) conclude that mHealth is a promising tool to train healthcare workers in sub-Saharan Africa.

The literature identifies some barriers and facilitators to the implementation of mobile learning and eLearning in sub-Saharan Africa (Asgary et al., 2019; Ayanore et al., 2019; Barteit et al., 2018; Holst et al., 2021; Kynge, 2020; Masika et al., 2015; Olum et al., 2020). However, little is known about the needs of health professionals in sub-Saharan Africa in their role as educators providing mobile learning or as learners. Furthermore, to the author's knowledge, there is no research on the potential special needs of educators and learners that may be encountered when teaching or learning about digital rehabilitation through mobile learning in sub-Saharan Africa.

Therefore, this study investigates the needs of working and aspiring health professionals in sub-Saharan countries in their roles as educators and as learners concerning mobile learning on digital rehabilitation.

1.2 Research Question

Considering the healthcare situation and upcoming digitization in the Sub-Saharan African region, as described in the previous chapter, this master thesis aims to answer the following research question:

What are the needs of working and aspiring health professionals in sub-Saharan Africa in their roles as educators and learners concerning mobile learning on digital rehabilitation?

To answer this research question, an exploratory cross-sectional study was conducted using a mixed methods questionnaire in an online survey. The materials and methods used for this study are described in detail in chapter 3.

1.3 Goal and aim of the study

The goal of the study was to gain insight into how mobile learning units of digital rehabilitation should be designed for working and aspiring health professionals in sub-Saharan Africa, with the aim to develop a digital guidebook for educators.

Therefore, one of the study's objectives was to perform a comprehensive systematized review of the literature on the effectiveness as well as barriers and facilitators to mobile learning for health professionals in sub-Saharan Africa. The other objective was to conduct an exploratory cross-sectional study using a mixed methods questionnaire in an online survey. The empirical study was done to explore the needs of working and aspiring health professionals in these countries in their roles as educators and learners concerning mobile learning in general and mobile learning on digital rehabilitation.

Based on the literature and the survey findings, a digital guidebook was developed that provides educators with guidance for creating mobile learning units on digital rehabilitation for health professionals in sub-Saharan Africa. The guidebook is designed as interactive learning videos built on the story of an educator who begins creating a mobile learning unit on digital rehabilitation in sub-Saharan Africa, targeting health professionals.

2 Theoretical background

This chapter provides background information on current health systems' challenges, focusing on the shortage of skilled health workers worldwide and especially in sub-Saharan Africa. Thereupon, it presents the current technological infrastructure in this region and the opportunities that new technologies have brought to healthcare, particularly to rehabilitation and education of qualified health professionals. In addition, the facilitators and barriers are presented.

2.1 Challenges in health systems and emergent opportunities through new technologies

According to the WHO, “a health system consists of all organizations, people and actions whose primary intent is to promote, restore or maintain health” (World Health Organization, 2007, p. 2). This does not just include public healthcare facilities. It is a complex network of private and public health services, as well as the care for a sick relative, health insurance, health education, and many more (World Health Organization, 2007). Especially in low-income countries, weak health systems are a hindrance to improving healthcare (Haines & Victora, 2004).

The WHO`s (2007) framework for action on strengthening health systems defines six building blocks of a health system based on the functions identified in the World health report 2000 (World Health Organization, 2000). These blocks are “service delivery; health workforce; information; medical products, vaccines and technologies; financing; and leadership and governance (stewardship)” (World Health Organization, 2007, p. V). To achieve better health outcomes, a country's health system must be strengthened in all areas, and only if all blocks fulfill a certain basic function, the goal of improving health can be achieved. Consequently, functioning health systems include a procurement and distribution system that delivers the needed interventions, as well as a sufficient and qualified health personnel (World Health Organization, 2007).

Besides many other challenges that health systems face, such as aging populations, management of epidemics or pandemics, and caring for the chronically ill, the growing shortage of healthcare workers worldwide is a major concern (World Health Organization, 2007).

The existing lack of 7.2 million health professionals, including, for example, physicians, nurses, and pharmacists, is expected to grow to 12.9 million by 2035 (Campbell et al., 2013). Considering the growing population, the increase in the number of people needed for healthcare is plausible.

As early as 2005, the WHO recognized the potential advantages of technology in various areas of healthcare and included the use of digital technology in its strategy with the adoption of the World Health Assembly resolution WHA58.28 on electronic health (eHealth) (58 World Health Assembly, 2005). This step was followed by several other resolutions on eHealth and digital health with the aim of promoting universal health for all people (66 World Health Assembly, 2013; 71 World Health Assembly, 2018).

The term digital health is broad and comprises the areas of eHealth as well as the use of new areas of development such as Big Data and artificial intelligence (71 World Health Assembly, 2018). The areas of eHealth are well summarized by the WHO in their definition of eHealth as “the cost-effective and secure use of information and communications technologies in support of health and health-related fields, including healthcare services, health surveillance, health literature, and health education, knowledge and research” (58 World Health Assembly, 2005, p. 109).

Several years have passed since this definition was made, and information and communication technologies (ICTs) have continued to develop. Since 1970, both central processing unit (CPU) speed and memory capacity have doubled every two years. At the same time, the size of the chips used for data storage and processing has been noticeably reduced (Seel, 2022). Digital devices have changed from phones and large computers with a very limited number of applications to a range of small and high-performance devices such as smartphones, smartwatches, and other wearables. This evolution has impacted many areas of the economy and has also changed the field of eHealth in healthcare (Istepanian et al., 2006). This resulted in the term mHealth to describe “medical and public health practice supported by mobile devices” (WHO Global Observatory for eHealth, 2011, p. 6). It is a component of eHealth, but still encompasses all areas covered by eHealth, with the difference that the end user accesses the service via a mobile device (WHO Global Observatory for eHealth, 2011). It can therefore also be seen as the evolution of eHealth (Istepanian et al., 2006) and primarily includes the main functions of a mobile phone, which are short messaging service (SMS) and voice transmission, in combination with more advanced technologies such as global positioning system (GPS), Bluetooth, and general packet radio service (GRPS) (WHO Global Observatory for eHealth, 2011).

Meanwhile, 95% of urban and 71% of rural areas worldwide are covered by a 4G mobile network, showing that digitization is on the rise (International Telecommunication Union, 2020). However, common challenges in digital healthcare such as poor management, limited access to materials and equipment, infrastructure limitations, and inadequate education exist (World Health Organization, 2019).

Nevertheless, in recent years, it has become increasingly clear that the use of technology to deliver healthcare and educate more health professionals is part of the solution to healthcare challenges. Therefore, the WHO, in collaboration with the International Telecommunication Union, has designed a toolkit to assist the establishment of a strategy for a national eHealth policy (World Health Organization & International Telecommunication Union, 2012).

With the development of ICTs, digital healthcare is a potential solution to the two main problems of healthcare, which are access and distance (World Health Organization, 2019). These problems apply especially to low- and middle-income countries, where many people live in rural areas. In sub-Saharan Africa, low- and middle-income countries account for the largest share (86%) (The World Bank Group, n.d.-a).

The current coverage and education of health professionals in sub-Saharan Africa is described in the following chapter.

2.2 Healthcare workforce in sub-Saharan Africa

Sub-Saharan Africa includes 48 countries. For the current fiscal year 2022, The World Bank Group[1] (n.d.-a) classified 23 of them as low-income countries (48%), 18 as lower-middle-income countries (38%), and seven as upper-middle-income to high-income countries (14%), with only the Seychelles classified as a high-income country.

Although some countries have a higher income level than others, the sub-Saharan countries are united by a poor healthcare system. A major problem is the low number of health workers in these countries, which is expected to decline even more (World Health Organization, 2016b).

[1] https://datahelpdesk.worldbank.org/knowledgebase/articles/906519

This shortage becomes even more apparent when looking at the number of doctors and nurses in sub-Saharan Africa. In 2017, the number of physicians per 1,000 people in the low- and lower-middle-income countries in sub-Saharan Africa ranged from 0.03 in Togo to 0.21 in Angola. With 2.31 physicians per 1,000 people, Mauritius was the only country among the upper-middle-income countries in sub-Saharan Africa to report more than one physician per 1,000 people. The other upper-middle-income countries reported 0.4 to 0.91 physicians per 1,000 people. For 2017, no data was available for the high-income country, Seychelles. These figures show that in 2017, an average of 0.23 physicians were responsible for 1,000 people in sub-Saharan Africa. The average number of nurses and midwives in these countries in 2018 was 1 per 1,000 people. Again, there is wide variation between countries, ranging from 0.23 nurses per 1,000 people in Chad to 3.9 in Eswatini (The World Bank Group, n.d.-b).

At the very least, there has been an increase. From 2000 to 2017, the number of physicians per 1,000 people doubled. However, it is still very low. By comparison, in 2018, Germany and Austria had 4.2 physicians per 1,000 people, which is about 18 times more. The number of nurses and midwives in 2018 was 13.3 per 1,000 people in Germany and 7.1 in Austria (The World Bank Group, n.d.-b) (see Figure 1).

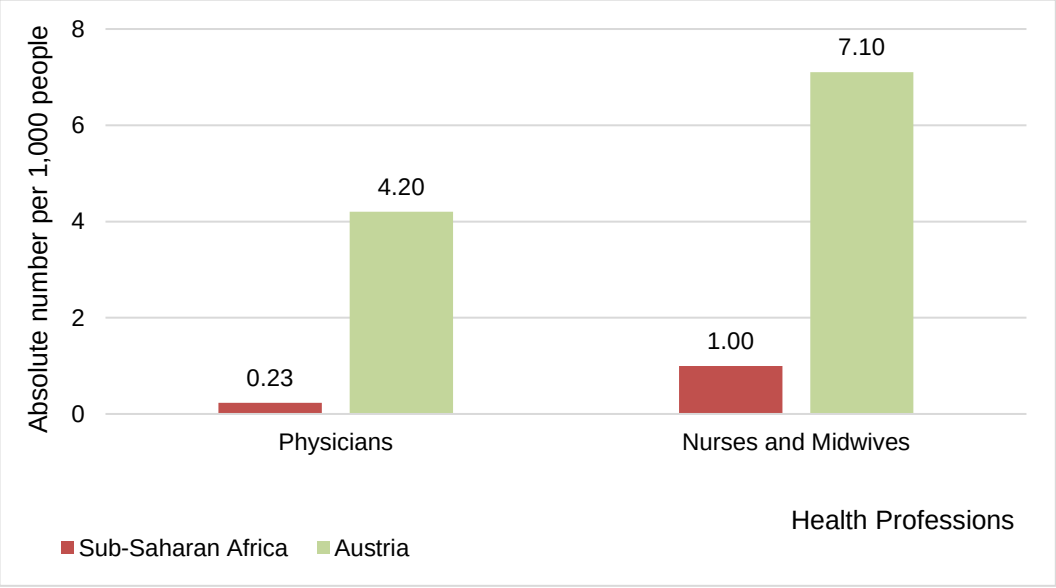


Figure 1: Comparison of the average number of physicians and nurses and midwives in sub-Saharan Africa (excluding high-income countries) and Austria responsible for 1,000 people (The World Bank Group, n.d.-b). Own illustration.

Physiotherapists are another important health profession when it comes to rehabilitation. According to the Annual Membership census of World Physiotherapy in 2020, in which 21 out of the 25 African member countries participated, only South Africa reported having more than one physiotherapist per 10,000 people. The average is reported with 0.2 physiotherapists per 10,000 people (World Physiotherapy, 2020a). Other health professions that are part of the rehabilitation sector as well, such as occupational therapists and speech therapists, do not even exist in some sub-Saharan countries (Kamenov et al., 2019).

Training more health professionals is necessary to solve the problem of the severe shortage in the healthcare workforce in this area. In addition, the education of a cadre of health professionals on evaluation and monitoring is also important to strengthen health systems at the country level (Ayanore et al., 2019). However, many of these countries also lack educational institutions. In 2010 sub-Saharan Africa had a population of about one billion people and only about 134 medical schools with about 6000 graduates per year. To compare, Western Europe has about 300 medical schools and about 42,000 graduates per year for 200 million people, which is a fifth of the population in sub-Saharan Africa (Frenk et al., 2010). As the number of medical schools, the number of physiotherapist entry level education programs in sub-Saharan Africa is very low. With 72 entry level education programs in the 21 responding member states, Africa has the lowest average of 0.5 programs per 5 million people globally. In 2020, these programs produced about 1,803 new physiotherapists for 21 countries (World Physiotherapy, 2020a).

Further, rehabilitation and physiotherapy are not yet well known or accepted in many low-income countries, making it challenging to recruit new students, and the lack of professional recognition as a physiotherapist often results in a change of profession (Barth et al., 2021). In addition, several medical and physiotherapy graduates from countries in sub-Saharan Africa migrate to wealthier countries, which further reduce the supply of quality healthcare and create a shortage of educator for prospective medical students (Ndetei et al., 2010). In some countries, another problem is lower government subsidies for formal universities. As a result, more students have to pay higher fees which allow universities to cover their financial expenses, leading to even fewer people being able to afford to go to university (Ndetei et al., 2010).

In recent years, there has been growing interest in community health workers (CHWs), which are also called community-based health workers or lay health workers, in sub-Saharan Africa (Cometto et al., 2018; International Labour Organization, 2012; Lewin et al., 2010). Without a professional education, but some training, they take over tasks of basic healthcare delivery by visiting families in their homes, either voluntarily or for pay (Lewin et al., 2010). They are based in the communities and their scope of work is very diverse and includes preventive, promotive, and curative services (Cometto et al., 2018). The current tasks of CHWs are summarized in the International Standard Classification of Occupations of the International Labour Organization (2012). They include providing health information to individuals and the community, collecting data to monitor a person's health, distributing medical supplies, and helping people access health services. Through their work, they provide a link between healthcare providers and communities (International Labour Organization, 2012).

Several studies have shown that the work of CHWs offers promising potential for improving healthcare in the areas of infectious diseases (Mwai et al., 2013; Smith Paintain et al., 2014; Wright et al., 2015) and non-communicable diseases (Mishra et al., 2015; Raphael et al., 2013; van Ginneken et al., 2013) as well as in reproductive health, child, newborn and maternal health (Black et al., 2017; Gilmore & McAuliffe, 2013; Glenton et al., 2011; Lassi et al., 2010; Lewin et al., 2010) and neglected tropical diseases (Vouking et al., 2013).

Unfortunately, the number of CHWs in recent years is only available for Guinea for 2016 with 0.52 per 1,000 people. This number is not very high, but compared to the number of physicians this year, which was 0.08 per 1,000 people, it is 6.5 times higher (The World Bank Group, n.d.-b).

CHWs are close to the community, which allows them to better reach people in rural areas, and they do not need a long education to perform their tasks. Task-shifting of health professionals to CHWs in low- and middle-income countries has the potential to be part of the solution to provide better access to healthcare (Joshi et al., 2014).

However, to reach the aim of the universal health coverage adopted by the WHO in 2005 (58 World Health Assembly, 2005), skilled health professionals are needed, and the use of digital technology offers the potential to close the skills gap (World Health Organization, 2016a). Therefore, the current state of digitization in sub-Saharan Africa and its healthcare system is described in the next chapter.

2.3 Digitalization in sub-Saharan Africa and in its healthcare

This chapter provides an overview of the development and current situation of technological infrastructure in sub-Saharan Africa. Further, it gives an overview of how mobile technology is being used in healthcare in this region.

2.3.1 Internet and mobile technology in sub-Saharan Africa

Within 20 years, the average percentage of Internet users in sub-Saharan Africa has increased from 1% in 2000 to 29% in 2020. However, according to the International Telecommunication Union (n.d.-a), they are unevenly distributed in the individual countries (see Figure 2). An even greater increase was recorded in mobile cellular subscriptions. From 1.72 subscriptions per 100 people in 2000, these increased to 93.59 per 100 people in 2020 (see Figure 3) (International Telecommunication Union, n.d.-b).

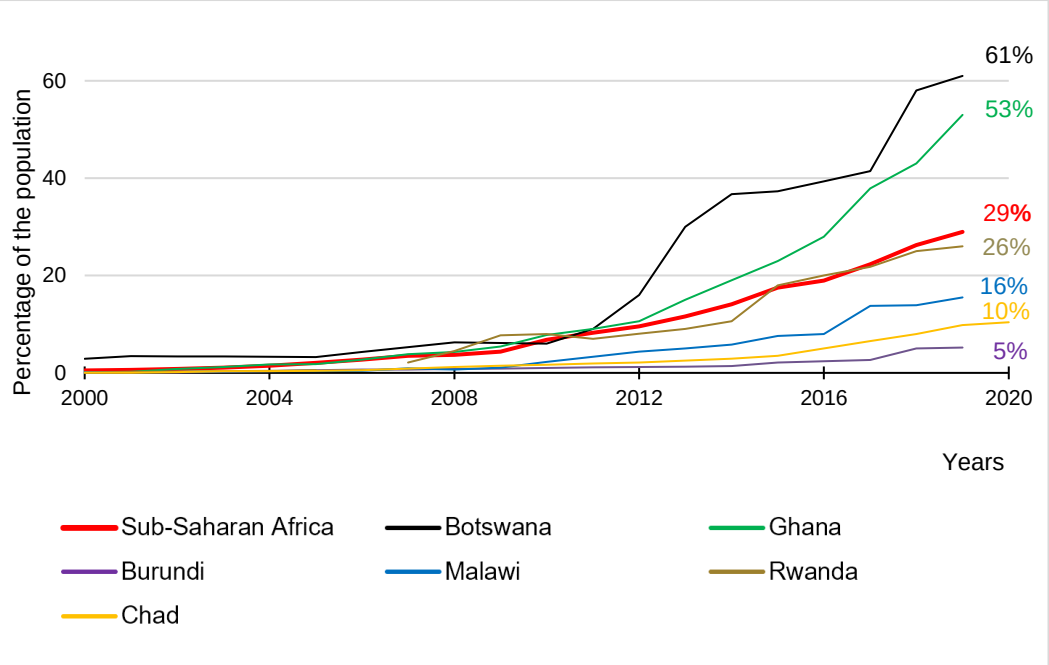


Figure 2: Development of the percentage of Internet users in the population in a selection of countries in sub-Saharan Africa compared to the average percentage in the region (excluding high-income countries) | Percentages rounded to a whole number (International Telecommunication Union, n.d.-a). Own illustration.

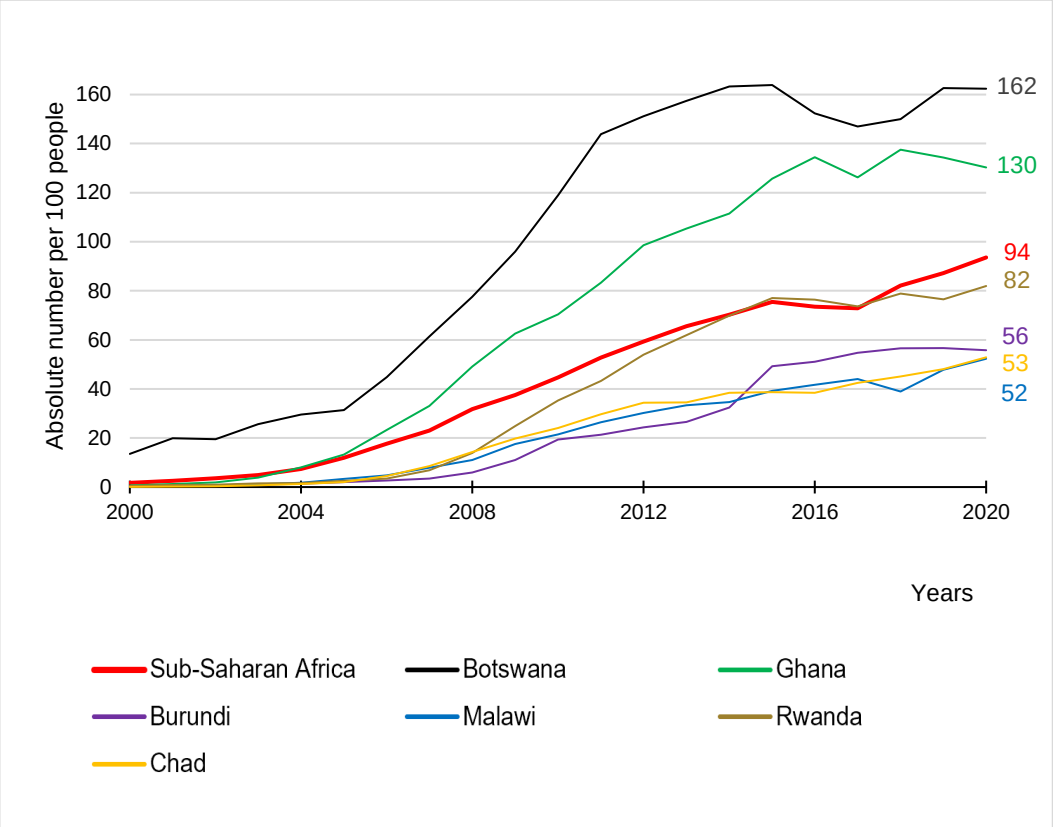


Figure 3: Development of the mobile cellular subscriptions per 100 people in a selection of countries in sub-Saharan Africa compared to the average in the region (excluding high-income countries) | Rounded to a whole number (International Telecommunication Union, n.d.-b). Own illustration.

Since in every region of the world the percentage of households that own a computer is lower than the percentage of households that have access to the Internet, it is becoming clear that access to the Internet is no longer primarily through computers (International Telecommunication Union, 2020).

However, data from the International Telecommunication Union (2020) show a gap between Internet access in urban and rural areas. This gap is much larger in low-income countries compared to high-income countries. In Europe, for example, the difference is 10%, while in Africa it is 21%. Here, it has to be noted that Internet access in rural areas in Europe is still at 78%. In rural areas of Africa, it is only 6% (International Telecommunication Union, 2020).

With mobile phones and smartphones now being the primary devices for Internet access, especially in Africa, network coverage is critical for the population to access the Internet.

Worldwide, 95% of the urban area is covered by 4G mobile networks. In rural areas of the world, only 71% of the population has a 4G network. Compared to Europe, where 4G network coverage is 100% in urban areas and 89% in rural areas, while the rest is almost exclusively covered by 3G networks, in Africa the gap in 4G network coverage between rural and urban areas is enormous (see Figure 4) (International Telecommunication Union, 2020). This difference in network coverage is possibly part of the explanation for the gap mentioned above between Internet access in rural and urban areas in Africa.

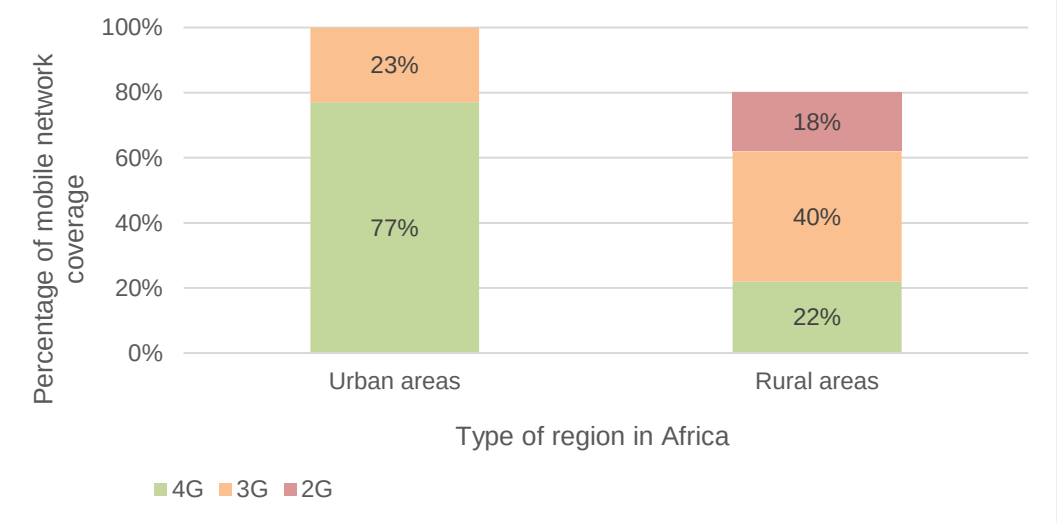


Figure 4: Percentage of mobile network coverage by type and region in Africa (International Telecommunication Union, 2020). Own illustration.

However, coverage by 4G mobile networks in Africa has improved noticeably. Compared to other regions, Africa is the only region that recorded a considerable growth of 21% in the 4G rollout in 2020 (International Telecommunication Union, 2020), allowing more people to access the Internet. In addition to network coverage, ICT services must also be financially affordable. The affordability target of the broadband commission is 2% of gross national income per capita (GNI p.c.) for a mobile or voice data basket (International Telecommunication Union, 2020). While Europe is already below this target, data prices in Africa clearly exceed 2% of GNI p.c. and cost an average of 11.4% of GNI p.c. for mobile data and 12% for voice data (International Telecommunication Union, 2020). The high cost of mobile data is another reason why fewer people use the Internet in Africa compared with Europe, even though there is network coverage in the urban areas.

Several studies have evaluated the ownership of digital devices within the African population (DataReportal, 2021a, 2021b; Masika et al., 2015; Olum et al., 2020): All show that most people who own a smart device own a smartphone or mobile

phone. 94% of the students in the Bachelor of nursing, surgery, and medicine at Makerere University in Uganda own a smartphone, and only 61.2% own a computer (Olum et al., 2020). The data on digital device ownership in Ghana and Nigeria (DataReportal, 2021a, 2021b) shows similar results (see Figure 5).

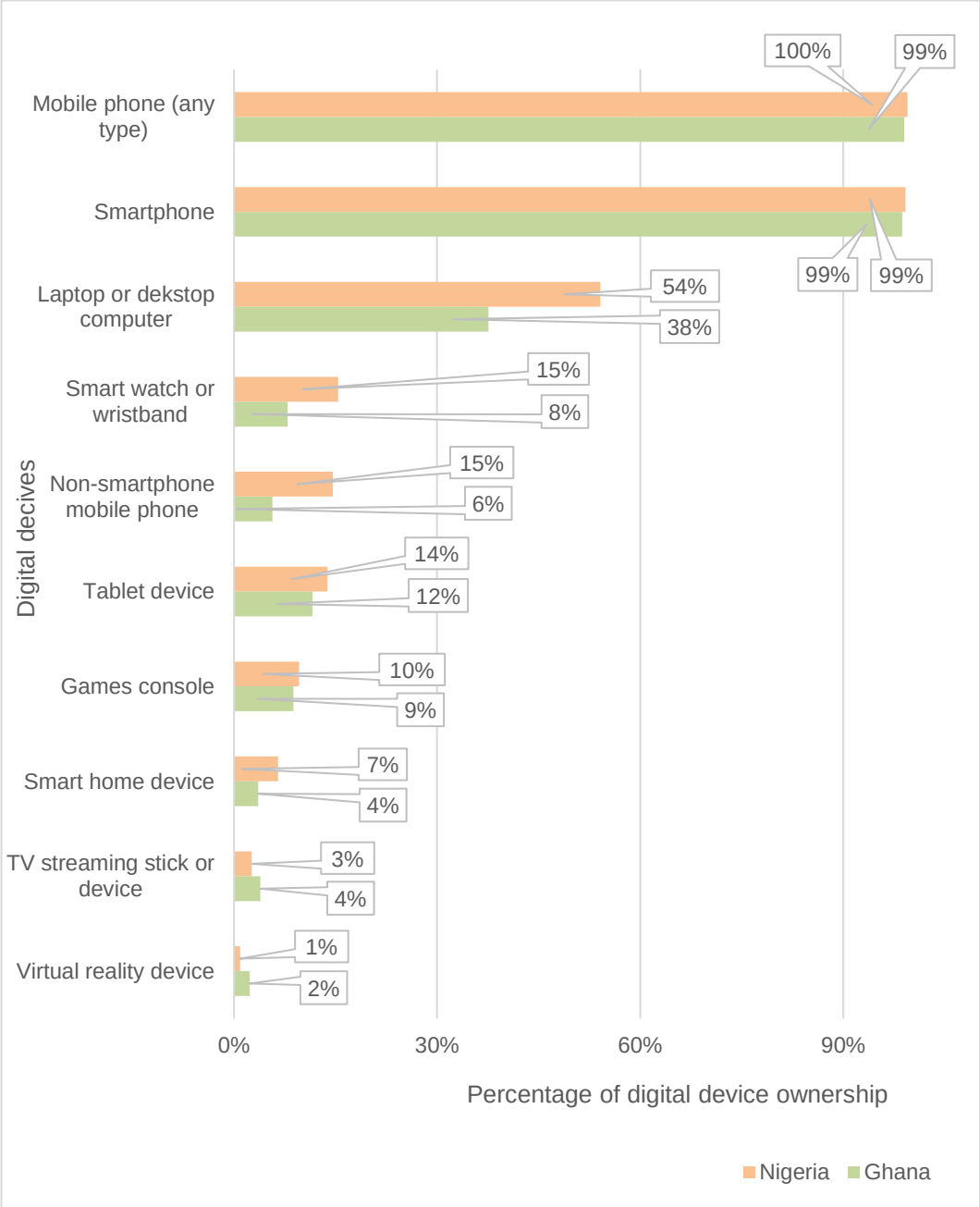


Figure 5: Percentage of digital device ownership in Nigeria and Ghana in 2020 among Internet users aged 16-64 years | Rounded to a whole number (DataReportal, 2021a, 2021b). Own illustration.

2.3.2 Mobile technology in healthcare in sub-Saharan Africa

Increasing access to a mobile network and digital devices among African populations has impacted various markets, daily life, and healthcare in sub-Saharan Africa.

A study of the World Health Organization (2016a) shows that 83% of the African countries report at least one mHealth initiative in 2016. However, the number of mHealth programs varies widely by region (Lee et al., 2017). In sub-Saharan Africa, 487 mHealth programs were implemented between 2006 and 2016, including 287 programs in 17 countries in the eastern region and 145 programs in 13 countries in the western region. Only 55 mHealth programs were conducted in the other 18 sub-Saharan countries (Lee et al., 2017).

These mHealth initiatives are in several areas of medicine in sub-Saharan Africa (Betjeman et al., 2013). Many of them involve similar functions like communicating via text or voice with patients or other health professionals, monitoring patients' data (Betjeman et al., 2013; Braun et al., 2013; Chang et al., 2013), and clinical decision making (Amoakoh et al., 2019; Chang et al., 2013).

A review conducted in 2013 on studies in sub-Saharan Africa on mHealth shows that the use of these functions of mobile technology improves patient monitoring and reduces costs at the same time (Betjeman et al., 2013). The same review found an improvement in the communication among healthcare workers, most notable in rural regions. Moreover, emergency and disaster response, medication adherence, and the storage and analysis of patient information hold initial promise (Betjeman et al., 2013). This improves the quality of care, makes medical services more efficient, and builds capacity for program monitoring (Braun et al., 2013).

Research on the readiness of healthcare providers in northern Ghana to adopt electronic health records found that there is also a desire for electronic documentation (Abdulai & Adam, 2020). Willingness to adopt electronic health records was highest among individuals who were younger, male, had good computer skills, and had been in the workforce for some time. However, some health providers were concerned about the potential impact of an electronic health records. Abdulai & Adam (2020) propose that health professionals need to be trained on ICT in healthcare during their studies to enable successful implementation and maintenance of electronic health records. In addition, workshops must be offered to working health professionals to improve their knowledge on this topic (Abdulai & Adam, 2020).

Apart from education on ICT in healthcare, a realist review on mHealth interventions for non-communicable disease management found that contextual factors also contribute to the success of mHealth in sub-Saharan Africa (Opoku et al., 2017). Depending on the needs, predisposing characteristics, and enabling resources, providers and patients may be more or less convinced that a mHealth intervention is effective, which finally contributes to the success of the intervention. Their review found that a common communication language and a positive attitude are the most important predisposing characteristics. According to the needs, a lack of capacity among first-contact providers and a high burden of disease are factors that contribute to the perception that an mHealth intervention is beneficial and user-friendly. As enabling resources, Opoku et al. (2017) found appropriate regulatory policies, a stable mobile network, and accessible maintenance services.

Barriers to the implementation of mHealth in Sub-Saharan Africa include knowledge, operating costs, infrastructure, and policy (Betjeman et al., 2013). A known barrier to the use of mHealth for CHWs in Kampala, Uganda, is Internet access at home (Chang et al., 2013).

When analyzing the literature on mHealth interventions in one sub-Saharan country, such as the study by Chang et al. (2013) mentioned above, care must be taken not to generalize about the other countries in the region. This is important because of differences in landscape, mobile network coverage, and proportion of urban and rural populations. Therefore, further research needs to be conducted in sub-Saharan Africa in a variety of countries with different infrastructures to determine the feasibility of mHealth and its potential benefits (Betjeman et al., 2013).

MHealth is also used for digital rehabilitation in telemedicine, which is defined as medical services that include all types of use and application of modern ICT and are characterized by a direct relationship to the patient (Fischer et al., 2016). Since this study focuses on educating working and aspiring health professionals on digital rehabilitation, the next chapter gives an overview of the technologies already used in rehabilitation, the current evidence, and challenges in this area.

2.4 Digital rehabilitation, its current evidence, and remaining challenges

The overall aim of rehabilitation is to optimize functional capacity (Cieza, 2019). It aims to improve “a person's ability to participate more fully” (Krug & Cieza, 2017, p. 439) in daily life by delivering interventions to improve functioning in mental, physical, and social domains (Cieza, 2019; Krug & Cieza, 2017).

Since the functioning of each individual itself affects his or her functioning in society and may, for example, enable a person to return to work or education, it is an important area of the healthcare system (Krug & Cieza, 2017).

A study by Cieza et al. (2020) on the global need for rehabilitation shows that in 2019, about 2.41 billion people worldwide would have benefited from rehabilitation and that every third person suffering from an illness or injury needs rehabilitation at some point. However, more than two-thirds of people with disabilities who need rehabilitation in the sub-Saharan countries Mozambique, Malawi, Zimbabwe, Zambia, and Lesotho do not receive it (Kamenov et al., 2019). In light of these numbers, the WHO initiated the Rehabilitation 2030 call for action to bring awareness to the growing rehabilitation needs and to strengthen rehabilitation in health systems (World Health Organization, 2017).

With the improvements in ICTs, rehabilitation options have also transformed. This has created the opportunity for digital rehabilitation to reach more patients and improve rehabilitation. Depending on various factors, digital rehabilitation holds potential benefits such as cost savings, shorter travel times, availability of services, and knowledge that would otherwise be inaccessible (Pramuka & van Roosmalen, 2009).

Several articles defining rehabilitation were reviewed to define digital rehabilitation for this study. This resulted in an adapted definition of digital rehabilitation for this study as the use of digital technology to deliver interventions that improve a person's ability to fully participate in daily life by enhancing physical, mental, and/or social functioning (Cieza, 2019; Krug & Cieza, 2017).

The various technologies used for rehabilitation range from simple applications already used by the general population in their daily lives, such as text and audio data transmission, to fully immersive virtual reality systems. Hereby, two types of data transmission are distinguished. The first one is the real-time or synchronous transmission, which includes, for example, videoconferences, phone calls, and live positioning via a GPS. The second transmission type is asynchronous, where data is stored and sent later. It is also called store and forward and encompasses, for

example, a text or photo sent by email or a podcast. Text is the oldest way of transmitting information and is usually asynchronous, but instant messengers come very close to synchronous transmission (Pramuka & van Roosmalen, 2009).

The distinction of synchronous vs. asynchronous is one of the dimensions also used by Wagner et al. (2008) in classifying eLearning programs (see chapter 2.5).

With improved technology, it is now possible to transmit live body positions without additional sensors. Kaia Health uses this technology for their users with knee or hip osteoarthritis to provide audiovisual feedback in real time during the training (Biebl et al., 2021). Furthermore, active video gaming over several weeks has been found to lead to at least similar improvements in physical performance as conventional exercises in people with chronic respiratory disease, and in addition, it is more enjoyable (Simmich et al., 2019). Wearables like fitness trackers and smartwatches are also used to support rehabilitation (Anttila et al., 2021; Hunter et al., 2021). In a one-year study for cardiac patients, participants took part in three five-day, face-to-face rehabilitation periods with exercise and interprofessional classes. Between the interventions at the rehabilitation center, they received web-based coaching, an activity tracker, and a monthly call with one of the physiotherapists. In addition, they were able to share their experiences with the other participants. In this study, however, the digital therapy elements of rehabilitation were rated as less important than the possibility of contacting other group members remotely. The contact was rated as the most important aspect by the participants (Anttila et al., 2021), indicating that interaction with other patients needs to remain a factor to be considered in digital rehabilitation. The study conducted by Hunter et al. (2021) observed the recovery of patients after a severe COVID-19 with data from a smartwatch. The rehabilitation program was reviewed and adjusted remotely by an interdisciplinary team using collected data about the person's activity level, supported by video or phone calls with the participants. The collected data included resting heart rate, minutes of sedentary time, number of steps, and other physical activities such as cycling. Based on this data, it was possible to identify whether a patient had problems recovering. In such cases, a team member could immediately call the person and ask if there was a particular problem.

However, digital rehabilitation is not limited to the care of acute musculoskeletal or internal medicine patients. Studies have been conducted with neurological patients to train cognitive functions and language (Munsell et al., 2020) and with patients with psychosomatic problems (Keller et al., 2021). The study by Keller et al. (2021) showed that participation in Internet-delivered group therapy for depression led to reduced symptoms of anxiety and depression after the rehabilitation.

In recent years, digital rehabilitation has seen a massive increase in research. Many studies have been conducted, and 21 systematic reviews on telerehabilitation have been published until 2018. However, it is still a new and evolving field in the context of decades of research (Russell & Theodoros, 2018). A systematic literature review by Tonga et al. (2020) found that in the medium-term digital rehabilitation interventions are likely to help older people to improve physical activity and quality of life. An umbrella and mapping review with meta-meta-analysis conducted by Suso-Martí et al. (2021) in different medical fields on the effectiveness of telerehabilitation found that digital rehabilitation provides positive outcomes compared to traditional rehabilitation methods in physiotherapy practices.

Despite the benefits and opportunities of digital rehabilitation, some challenges still need to be overcome. Vaezipour et al. (2020) assessed the quality and content of 103 mobile applications for people with speech disorders and found a lack of evidence for the clinical benefits. In addition to the positive effects of digital rehabilitation interventions for the elderly, Tonga et al. (2020) also recognized an uncertainty on vertigo, falls, and short-term effects on physical activity.

Apart from the fact that there is not yet sufficient evidence in some areas, another challenge of digital rehabilitation is the digital literacy of potential users (Brennan & Barker, 2008). According to Russel & Theodoros (2018), assistive technology should always be selected depending on the tasks that are planned in a digital rehabilitation session. However, the characteristics of the medical staff and the patient who will use the technology in the digital rehabilitation environment must be considered in the decision as well (Brennan & Barker, 2008). To successfully perform digital rehabilitation, both must be able to operate and use the technology. Hereby, special attention must be paid to patients, as some are physically or mentally impaired and therefore have limited or no use of certain technology (Brennan & Barker, 2008). Video conferencing, for example, is often used in telerehabilitation. With multiple participants, clients and the healthcare provider must apply new communication patterns, since only one voice, respectively the sound of one location is transmitted (Pramuka & van Roosmalen, 2009).

The result of the Annual Membership census of World Physiotherapy in 2020, in which 21 out of the 25 African member countries participated, showed that 67% of the member states are already authorized to offer telemedicine services (World Physiotherapy, 2020a). This is comparable to the European member states, where 76% are allowed to use telemedicine (World Physiotherapy, 2020b).

It becomes increasingly clear that it is essential to train health professionals worldwide in the use of digital technology. They need to know which technologies for digital rehabilitation are available on the market, be proficient in the use of it themselves and be able to decide which technology is suitable for which patient.

Apart from patient care, there are mHealth initiatives that aim to educate health professionals (58 World Health Assembly, 2005). This area of mHealth is presented in the next chapter, addressing the advantages, barriers, and effectiveness of digital learning in healthcare.

2.5 Digital learning to educate working and aspiring health professionals

Digital learning or eLearning is technology-enhanced education that encompasses teaching and learning (Ahmed, 2010; Tavangarian et al., 2004; World Health Organization, 2016a). It includes different media, settings, tools, and content to support the learning process (Ahmed, 2010; Ellaway & Masters, 2008; World Health Organization, 2016a).

In 2016 eLearning was already used by over 84% of the countries worldwide to educate medical students and doctors and is an important component in promoting universal health coverage (World Health Organization, 2016a). In the European, Eastern Mediterranean, and Western Pacific regions, the use of eLearning for students and in-service training ranged between 60% and 75%. In the African Region, the use of eLearning was only 48% (World Health Organization, 2016a). The report of the World Health Organization (2016a) indicates that eLearning is used primarily to train students in public health, medical, and nursing, while other professions such as dentists and pharmacists were left behind. Physiotherapists or other therapeutic professions were not mentioned in the report.

Depending on the type of eLearning, education takes place in the classroom or completely remotely (Sweileh, 2021), with electronic media ranging from Compact Disc Read-Only Memories (CD-ROMs) and Digital Versatile Discs (DVDs) to computer models in virtual patients (Ahmed, 2010; Kononowicz et al., 2014). Wagner et al. (2008) summarized the dimensions of eLearning programs and classified eLearning programs according to the dimensions of synchronicity, location, independence, and mode (see Table 1).

Table 1: Dimensions of eLearning programs. Adopted from Wagner et al. 2008 p. 27

Dimension and Attribute	Meaning	Example
Synchronicity		
Asynchronous	Content delivery occurs at a different time than receipt by student.	Lectured module delivered via email link or similar.
Synchronous	Content delivery occurs at the same time as receipt by student.	Lectures delivered via Webcast.
Location		
Same place	Students use an application at the same physical location as other students and/or the instructor.	Using a group support system to solve a problem in a classroom.
Distributed	Students use an application at various physical locations, separate from other students and the instructor.	Using group support system to solve a problem from distributed locations.
Independence		
Individual	Students work independently from one another to complete learning tasks.	Students complete e-learning modules autonomously.
Collaborative	Students work collaboratively with one another to complete learning tasks.	Students participate in discussion forums to share ideas.
Mode		
Electronic only	All content is delivered via technology. There is no face-to-face component.	An electronically enabled e-learning course.
Blended	E-learning is used to supplement traditional classroom learning (and vice versa).	In-class lectures are enhanced with hands-on computer exercises and/or pre-class exercises.

Each course element in an eLearning course has one attribute from each dimension. However, since a course often consists of multiple elements, multiple attributes of a dimension may be present in a course (Wagner et al., 2008).

The flipped classroom, for example, is a model consisting of at least two course elements. In the first course element, students study pre-recorded content before class and, in addition, conduct discussions or assignments on their own or in groups before class (Educause, 2012). Thus, the first course element is delivered exclusively electronically and consists of asynchronous content where students are distributed and learn individually and/or collaboratively. The second course element is a traditional classroom lesson (Educause, 2012), and therefore the content is delivered in the same place in a blended mode. The learning content is thus synchronous. Depending on the lesson, students learn individually and/or cooperatively in the classroom.

Literature reviews and studies have demonstrated several benefits of eLearning in healthcare (Ahmed, 2010; Harun, 2001; Nisar, 2004; Omar et al., 2011; Ruiz et al., 2006), which have been summarized by Ruggeri et al. (2013). Especially for people with inadequate local health professions education facilities, as is the case in sub-Saharan Africa (Frenk et al., 2010), it improves access to education and the quality of its content (Ruggeri et al., 2013). However, global barriers still exist to the wider adoption of eLearning programs in healthcare (World Health Organization, 2016a). The summarized advantages (Ruggeri et al., 2013) and determined global barriers to implementation (World Health Organization, 2016a) of eLearning are presented in Table 2.

Table 2: Advantages of eLearning in healthcare and global barriers to its implementation (Ruggeri et al., 2013; World Health Organization, 2016a). Own illustration.

Advantages of eLearning in healthcare	**Global barriers to the implementation of eLearning in healthcare**
Standardized delivery of classes	Lack of capacity
Accessibility and flexibility regardless of time and place	Availability of suitable eLearning courses
Unlimited access to materials	Human resources
Personal access to training	Funding
Time saving and lower training costs	Evidence on cost-effectiveness
Self-directed and self-determined learning	
Collaborative environment.	
Creates universal communities	
Just-in-time learning	
Monitoring employee training	
Faster and more efficient updating and maintenance of knowledge	

To investigate the effectiveness of eLearning in healthcare, a randomized controlled trial was conducted in the United Kingdom by Hadley et al. (2010) on remote eLearning versus classic classroom instruction for teaching evidence-based medicine to postgraduate medical students. They found that both teaching methods were identical in terms of effectiveness. Ilic et al. (2015) also explored how eLearning is used to teach evidence-based medicine. In their randomized controlled trial in Australia, they used a blended learning approach that included classroom, online, and mobile learning and compared it to traditional in-class lectures for graduate and undergraduate medical students. As with Hadley et al. (2010), there was no major difference between the students of the two groups in terms of evidence-based medicine competencies after the course. Both concluded that eLearning has the same effect on knowledge growth in evidence-based medicine as traditional teaching (Hadley et al., 2010; Ilic et al., 2015).

As explained above, the flipped classroom model involves a mix of traditional in-class lectures and online-delivered course material, but the material is provided and must be studied by the students prior to the lectures (Hew & Lo, 2018). The meta-analysis conducted by Hew and Lo (2018) shows that flipped classrooms, which use videos prior to face-to-face lectures, achieve even a significant improvement over traditional in-class lectures for health professional education. In addition, as with traditional education, the way content is delivered via eLearning impacts knowledge gain. Hereby, interactive elements such as quizzes in a flipped classroom to educate health professionals further increases effectiveness (Hew & Lo, 2018). An enhanced podcast that included PowerPoint slides with spoken commentary, combined with mental practice or modeling also resulted in higher knowledge retention and skill acquisition (Alam et al., 2016).

Apart from the effectiveness of the eLearning methods, students also consider the blended learning approach to be beneficial. A focus group revealed that students are very positive about blended learning and prefer a mix of in-class lectures and online learning (Ilic et al., 2015). The meta-analysis by Hew and Lo (2018) also reported that more participants prefer the flipped classroom to traditional teaching.

Just as the evolution of technology has led to the development of mHealth as a component of eHealth, the increasing availability of mobile devices has also influenced the education sector, resulting in the new domain of mobile learning, sometimes abbreviated as mLearning (Tudor Car et al., 2015). Mobile learning is comparable to eLearning, but the learning content is delivered to students via mobile devices (Tudor Car et al., 2015). These include “mobile phones, smartphones, personal digital assistants (PDAs), tablets and Moving Picture Experts Group-1 audio layer 3 (MP3) players” (Dunleavy et al., 2019, p. e12937) as well as phablets and wirelessly operated laptops (Tudor Car et al., 2015). Dunleavy et al. (2019) defined mobile learning as “any intervention using handheld, mobile devices connected through wireless connections to deliver educational content” (Dunleavy et al., 2019, p. e12937). Their definition is used for this study, thus excluding wireless laptops to focus more on smaller devices that are “small, autonomous and unobtrusive enough to accompany us in every moment in our every-day life, and that can be used for some form of learning” (Trifonova & Ronchetti, 2003, p. 1794). Since eLearning includes mobile learning, the dimensions that Wagner et al. (2008) applied to eLearning (see Table 1) are also applicable to classify mobile learning. Further, mobile learning uses the same mobile technologies as mHealth that were described in chapter 2.1. These are primarily functions of a mobile phone such as SMS, multimedia messaging service (MMS), and voice transmission along with other types of digital modalities like games and applications to exchange educational content (Tudor Car et al., 2015).

Since this study deals with the education of working and aspiring health professionals on digital rehabilitation through mobile devices, it deals with the connection between mobile technology, healthcare, and education. Figure 6 illustrates the relationships between technology, healthcare, and education. It takes up the terms mHealth and eHealth discussed in chapter 2.1 as well as the terms eLearning and mLearning in this chapter and classifies them according to their definitions.

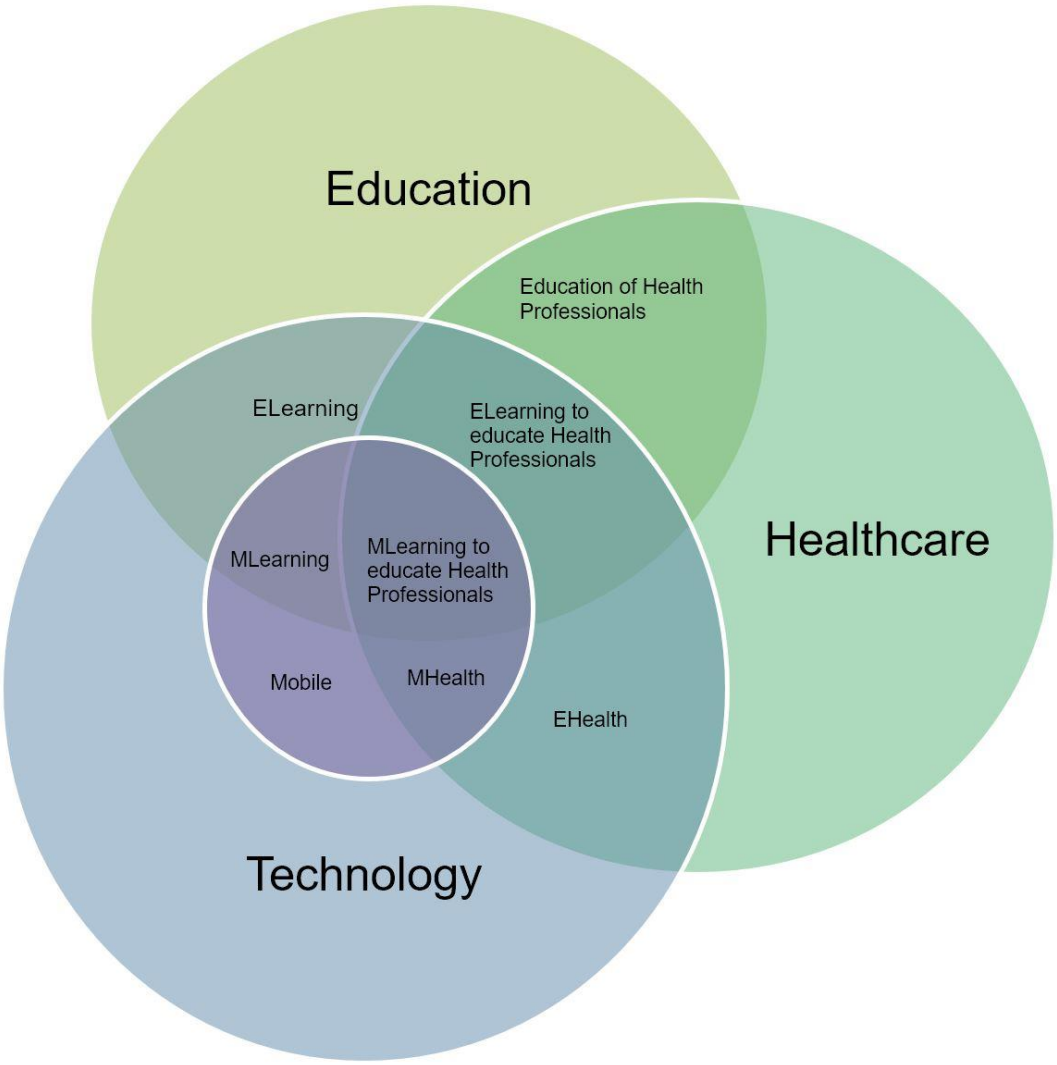


Figure 6: Relation between technology, education, and healthcare with the related terminologies. Own illustration.

As a result of the increasing importance of mobile devices, the World Health Organization's guideline (2019) to digital interventions for health system strengthening focuses primarily on education delivered through mobile devices. Apart from the advantages and global barriers to implementing eLearning in

healthcare (see Table 2) that also apply to mobile learning, it points out further challenges related to feasibility, acceptability, as well as gender, equity, and human rights of mobile learning for health professionals (see Table 3). However, according to the World Health Organization (2019), the recommendations and challenges mentioned in its guideline on digital interventions for health system strengthening apply only to the education of health professionals and not to undergraduate students.

Table 3: Challenges in delivering mobile learning to health professionals (World Health Organization, 2019). Own illustration.

Challenges in delivering mobile learning to health professionals
Feasibility
Network connectivity
Access to electricity
Usability of mobile devices
The need for sustained assistance and education for healthcare professionals
Acceptability
Concerns about validity and accuracy of the information
Concerns about possible adverse effects when used in interaction with patients
Gender, equity, and human rights
Poor network coverage
Access to electricity
Lower level of education and knowledge in the use of digital technology
Less resources, including poorer access to mobile devices

Mobile learning is increasingly seen as a key component of health professional education (Ruggeri et al., 2013) and research suggests that it may improve the knowledge of healthcare workers (World Health Organization, 2019). However, the effect on other outcomes is very uncertain, or no direct evidence exists. This includes skills and attitudes, as well as the performance of health professionals (World Health Organization, 2019).

Figure 7 summarizes the current evidence of the effectiveness of mobile learning for health workers compared to other digital health interventions on mobile devices.

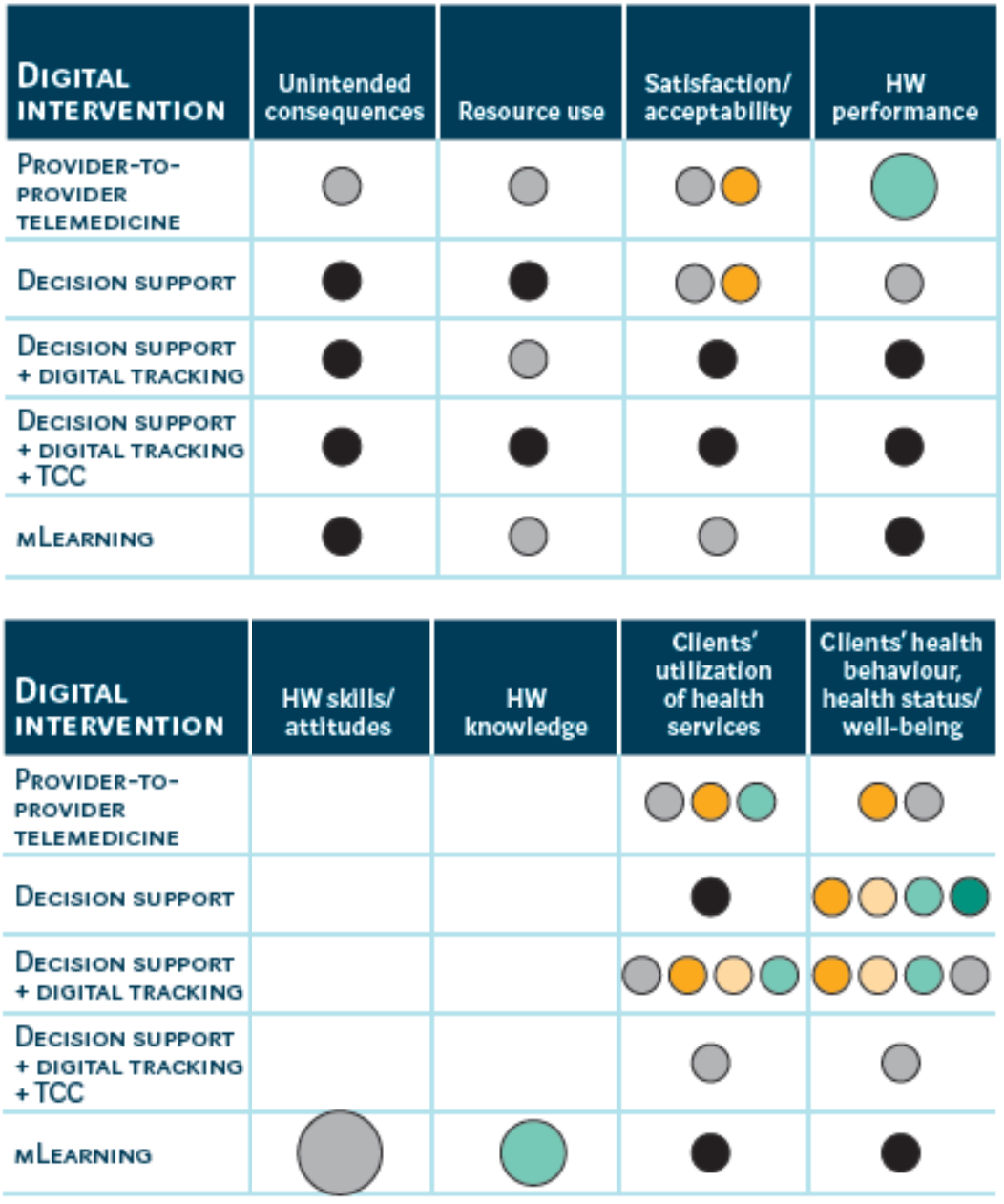


Figure 7: Evidence of the effectiveness for health worker interventions (World Health Organization, 2019, p. 115)

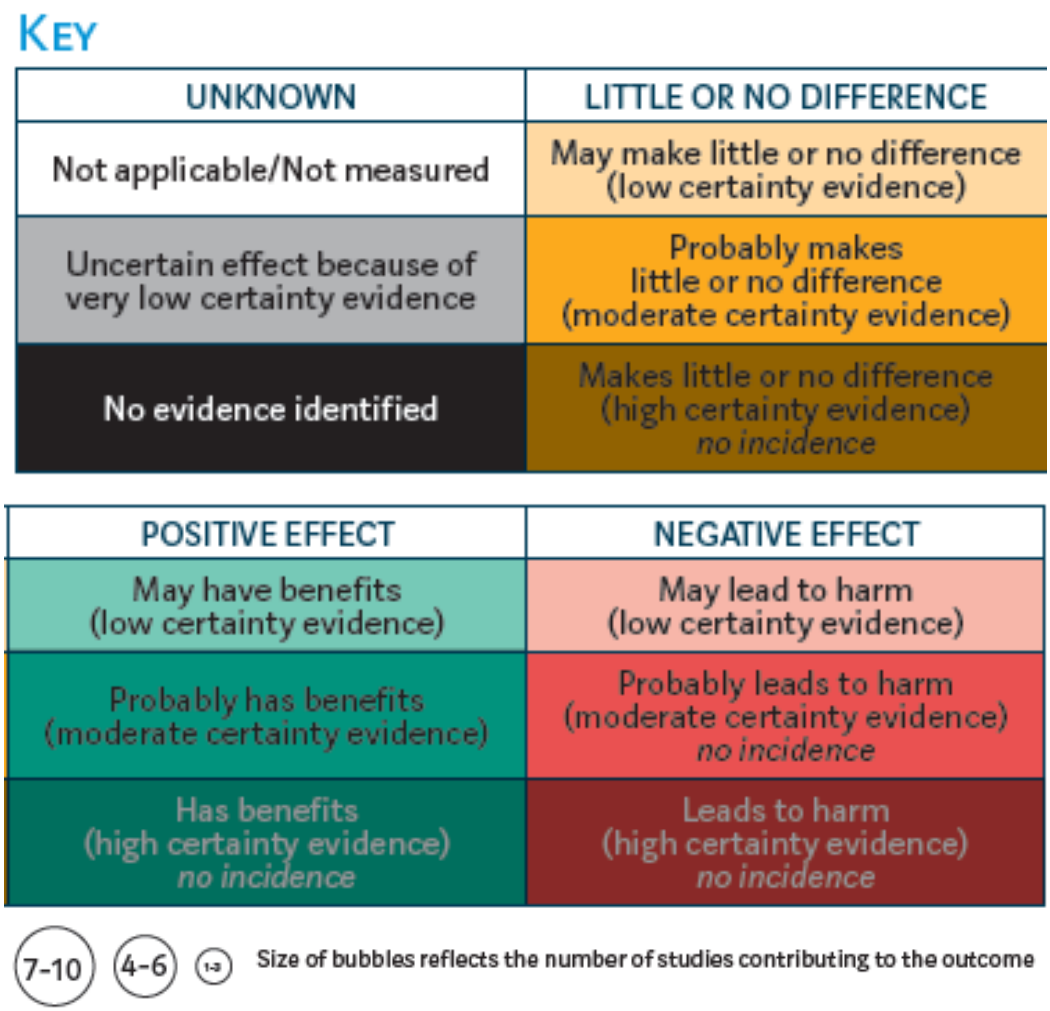


Figure 8: Key to Figure 7: Evidence of the effectiveness for health worker interventions (World Health Organization, 2019, p. 115)

In a recent bibliometric analysis by Sweileh (2021) on eLearning and mobile learning, in health science education, 4,567 documents were found, of which 48.7% are in social science, followed by 35.3% in medicine, and 23.8% in nursing. Medical/clinical education was the area with the largest number of documents (51.7%), nursing had the second highest number (26.3%), and health professions in general had the third highest number (14.9%). Sub-Saharan countries are the most likely to benefit from eLearning because of the large number of people living in rural areas and the inadequacy of educational facilities for health professionals (Frenk et al., 2010). However, only 2.3% of the documents in the analysis are from the African region, which is the lowest percentage (Sweileh, 2021). The analysis shows that most of the research was conducted in the northern hemisphere by high-income countries and that most documents originated from the European and American regions.

These figures show an interest in eLearning and mobile learning in the health sector, but little research has been done on this topic in low- and middle-income countries compared to high-income countries.

Despite the current lack of evidence on mobile learning in healthcare, the World Health Organization (2019) recommends digital education for postgraduate health professionals, noting that it should not replace, but complete, traditional methods of ongoing health education. They reason that the potential advantages of mobile learning outweigh the possible harms, as it creates an additional channel for healthcare education and allows a broader group of health professionals to access continuing education.

Already in 2006, health professionals were using the Internet and telephone to obtain information and knowledge about medical education (Curran, 2006). Nowadays, mobile devices have replaced fixed desktops in almost all areas and have become a main driver for investment in research on digital health, especially in low- and middle-income countries (World Health Organization, 2019).

Nevertheless, in sub-Saharan Africa, people face further challenges. Apart from lack of evidence, problems with users' digital literacy, broadband Internet coverage, access to a computer, and technical infrastructure are barriers to implementing and accessing digital services (International Telecommunication Union, 2020). These barriers are still more of a problem in low-resource countries than in high-income countries. However, as outlined in chapter 2.3, according to the International Telecommunication Union (2020), the technical infrastructure in sub-Saharan Africa has improved in recent years. This has led to an increase in the proportion of Internet users in the population of sub-Saharan Africa from 8.2% in 2011 to 28.9% in 2019 (International Telecommunication Union, n.d.-a).

The following chapter presents the effectiveness, specific barriers, and benefits of eLearning and mobile learning for health professionals in sub-Saharan Africa.

2.6 Digital learning in sub-Saharan Africa to educate working and aspiring health professionals

As outlined in chapter 2.3, the technological infrastructure in the sub-Saharan countries has improved over the last ten years, but remains far behind Europe (International Telecommunication Union, 2020). Poorer technical infrastructure and other contextual factors, such as a larger rural population and poorer public transportation than in high-income countries, create different advantages and specific barriers to e- and mLearning in healthcare in sub-Saharan Africa than in the European region.

Most of the research on digital learning in health science has been conducted in high-income countries (Sweileh, 2021), in which contextual factors differ from those in low-and middle-income countries. This chapter therefore focuses on the effectiveness of eLearning and its associated field of mobile learning, particular in sub-Saharan Africa for the education of working and aspiring health professionals, and the specific barriers and facilitators in this region.

2.6.1 Effectiveness and perceived usefulness of e- and mLearning to educate working and aspiring health professionals in sub-Saharan Africa

Several studies have been conducted on the use and effectiveness of mobile technology for educational purposes as well as on the attitudes toward eLearning and mobile learning of health professionals in sub-Saharan Africa (Barteit et al., 2018; Barteit, Jahn, et al., 2019; Barteit, Neuhann, et al., 2019; Braun et al., 2013; Hicks et al., 2021; Nishimwe et al., 2021; Olum et al., 2020; Otu et al., 2016; Pimmer et al., 2013, 2014; Rusatira et al., 2016).

A study examining knowledge of the Ebola virus conducted with healthcare workers in Nigeria using a tablet tutorial application found an 11% improvement in the average knowledge level (Otu et al., 2016). Also in Nigeria, Hicks et al. (2021) studied tablet-based video training aimed at health professionals in maternal, newborn, and child health. They found that knowledge improved by an average of 17% after the intervention. In Rwanda, a recent study by Nishimwe et al.(2021) used a smartphone application with animated instructional videos to educate nurses and midwives on Basic Emergency Obstetric and Neonatal Care. From pre- to post-intervention, the skills and knowledge scores of the participants increased noticeably.

Most of the studies that have been reviewed by O'Donovan et al. (2015) to assess the effectiveness of mobile technologies to educate health professionals conclude that mHealth is a promising tool to train health professionals in sub-Saharan Africa. This finding is supported by the review by Ayanore et al. (2019), who conclude that mHealth technologies are effective in disseminating information to remote populations and improving educational capacity in sub-Saharan Africa.

However, further and larger studies in sub-Saharan Africa are urgently needed to make a clear statement about the effectiveness of mHealth to educate health professionals (O'Donovan et al., 2015). Particularly in low-income countries such as those in sub-Saharan Africa, there is still limited evidence of the benefits of mobile learning in improving the skills and knowledge of health workers (Tudor Car et al., 2018).

In terms of perceived usefulness, several studies have shown that working and aspiring health professionals, as well as CHWs in sub-Saharan Africa, already use mobile technology to access educational content (Kynge, 2020; Masika et al., 2015; Pimmer et al., 2014; Rusatira et al., 2016). At the same time, the majority of educators, as well as learners, have a positive attitude towards mobile learning in health education (Asgary et al., 2019; Barteit, Jahn, et al., 2019; Hicks et al., 2021; Kynge, 2020; Olum et al., 2020)**.**

Certain factors were found to facilitate or hinder eLearning and mobile learning in the education of working and aspiring health professionals in sub-Saharan Africa. These are presented in the following chapter.

2.6.2 Barriers and facilitators in e- and mLearning to educate working and aspiring health professionals in sub-Saharan Africa

In terms of barriers to e- and mLearning in the education of health professionals in sub-Saharan Africa, poor Internet connectivity is the most frequently cited problem (Hicks et al., 2021; Kynge, 2020; Masika et al., 2015; Olum et al., 2020). This is followed by a lack of skills, for example, in eLearning (Olum et al., 2020), tablet use (Barteit, Jahn, et al., 2019), and technical know-how (Masika et al., 2015). Lack of relevant and up-to-date material (Barteit, Jahn, et al., 2019; Kynge, 2020), poor power supply (Hicks et al., 2021; Olum et al., 2020), and lack of time due to a high workload among working health professionals (Hicks et al., 2021; Kynge, 2020) are other barriers. Mobile subscriptions and smartphone ownership in Africa are on the rise (International Telecommunication Union, 2020), but limited access to relevant devices such as computers or smart appliances still seems to be a barrier (Kynge, 2020; Masika et al., 2015; Olum et al., 2020).

Among students in Nairobi who do not own a smart device, the cost is the main reason (Masika et al., 2015). Two studies also cited Internet costs as a barrier to accessing educational content (Masika et al., 2015; Olum et al., 2020). Further, Kynge (2020) found that the need for an email address to log into learning management systems is a hindrance for some people. Individuals without an email address are thus automatically excluded from certain e- and mLearning offerings.

Several factors that facilitate e- and mLearning are described in the literature. Of these, offline content (Barteit et al., 2018; Olum et al., 2020) and a preference to use educational content via an application (Kynge, 2020; Masika et al., 2015) are the two facilitators mentioned twice in the literature. However, the web browser was the main learning function used by students at the University of Nairobi (Masika et al., 2015). A blended learning environment (Olum et al., 2020) and continuous on-the-job training (Ayanore et al., 2019) were also reported as facilitators. Moreover, additional mobile learning, which consisted of three months of distance mentoring via text messaging on a smartphone after a traditional face-to-face course, was perceived by the participants as an essential addition to developing their skills (Asgary et al., 2019). Further, animations have been shown to be a preferred format for health education (Holst et al., 2021), and multimedia content as well as interactive exercises are useful for teaching skills and practicing procedural knowledge (Barteit et al., 2018). A study by Rusatira et al. (2016) shows that social media is used by 97% of physicians in Rwanda for medical education and that videos on YouTube are the preferred social media channel (69%), followed by Facebook (18%). Further, it was found that a good Internet connection, owning a computer, frequent use of academic websites, and good income positively affect the attitude towards eLearning (Olum et al., 2020). Factors that drive technology adoption include perceived usefulness, access to training content and technology, ease of use, and cost effectiveness (Hicks et al., 2021).

Other barriers and facilitators identified for the implementation of e- and mHealth initiatives in general and discussed in previous chapters may also apply to e- and mLearning. However, only those listed in this chapter were explicitly mentioned in the context of e- and m-learning for working and aspiring health professionals in sub-Saharan Africa.

As health professionals in sub-Saharan Africa increasingly access educational content via mobile devices, educational materials need to be more accessible via mobile learning by tailoring them to their needs (Kynge, 2020).

3 Material and methods

The study design and material and methods used for data collection, data analysis, and the development of the digital guidebook, are presented in this section.

3.1 Study Design

The study is an exploratory cross-sectional study using a mixed methods questionnaire in an online survey to investigate the needs of working and aspiring health professionals in sub-Saharan Africa on mobile learning concerning digital rehabilitation.

The study procedure consists of five steps (see Figure 9). First, literature research was conducted to develop a questionnaire. The literature research consisted of a *comprehensive systematized review of the literature* (Grant & Booth, 2009) and a *literature review* (Grant & Booth, 2009). In the second step, the questionnaire was developed based on the results of the literature research. The third step was the recruitment of participants while the online survey was open using the previously created questionnaire. After the survey was closed, the study results were evaluated in a fourth step. In a final fifth step, a digital guidebook for educators in the form of an interactive learning video was developed based on the results of the literature research and the online survey.

These five steps are described in more detail in the following chapters. The first four steps, summarized under the overall term data collection and analysis, are presented in chapter 3.2. The fifth step, the development of the digital guidebook from the information obtained, is described in chapter 3.3.

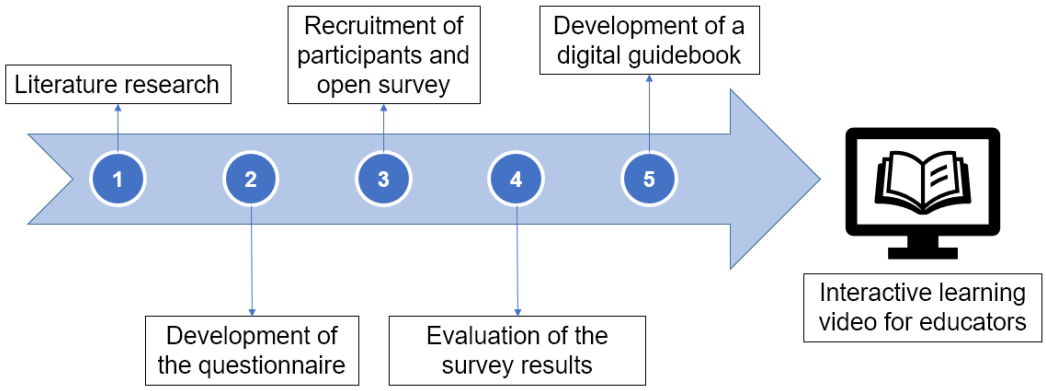


Figure 9: Study procedure. Own illustration.

3.2 Data collection and analysis

Data collection and analysis include the first four steps of the study process. Thus, the following sections present the conducted literature research, the development of the questionnaire for the online survey, the recruitment of participants, and the evaluation of the survey results.

3.2.1 Literature research

As mentioned in chapter 3.1, the literature research consisted of a *comprehensive systematized review* and a *literature review*.

The *comprehensive systematized review* (Grant & Booth, 2009) of the English-language literature was performed on the 26th of September 2021 in the PubMed database of the National Center for Biotechnology Information (NCIB) and the Journal of Medical Internet Research (JMIR). The research was conducted on two topics. The first topic is the effectiveness of existing mobile learning opportunities to improve the knowledge and skills of working and aspiring health professionals in sub-Saharan Africa. The second topic is the barriers and facilitators of mobile learning in sub-Saharan countries for health professionals. For each topic, keywords and synonyms were defined for the literature search in the PubMed database of the NCIB (see Appendix A). The synonyms of a keyword were linked with the Boolean operator OR. These word groups were then linked with the Boolean operator AND. No filters were applied. The keywords were also used for the literature search in JMIR (see Appendix B). When searching JMIR for the second topic on barriers and facilitators of mobile learning in sub-Saharan countries, a filter was set to display only hits from the journal JMIR Medical Education.

The *literature review* (Grant & Booth, 2009) on rehabilitation in sub-Saharan Africa, mobile learning, and digital rehabilitation was done in PubMed and JMIR between the 28th of September 2021 and the 5th of December 2021. To obtain information on digitization in sub-Saharan Africa, as well as statistics on the healthcare system in sub-Saharan Africa, the databases of Statista[2] and The World Bank were searched between the 28th of September 2021 and the 3rd of February 2022.

After reviewing the titles of the hits, the abstracts of the promising hits were screened. Interesting hits were further screened by a short scan of the document. Literature that was found to be relevant in this process was included in the study.

[2] https://www.statista.com/

Following the snowball principle, the bibliographies of the literature identified as relevant were searched for further potentially relevant sources on the respective topics.

Relevant hits of the literature research were read, and an Excel spreadsheet was created to capture the important contents of the sources. In the spreadsheet, the columns name of the source, author(s), year, journal, study design, and literally quotes were created. Relevant sources were listed in the rows. In addition, seven research areas commonly found in the sources were defined, and each source was assigned to an area. The cell containing the source's name was colored according to the assigned research area (see Figure 10). Further, 16 keywords were defined to provide an overview of the source content (see Figure 10). For this purpose, another column was created in the spreadsheet in which the keywords were entered. Both were done gradually during the literature screening process and were intended to simplify the subsequent search for a particular source and its content.

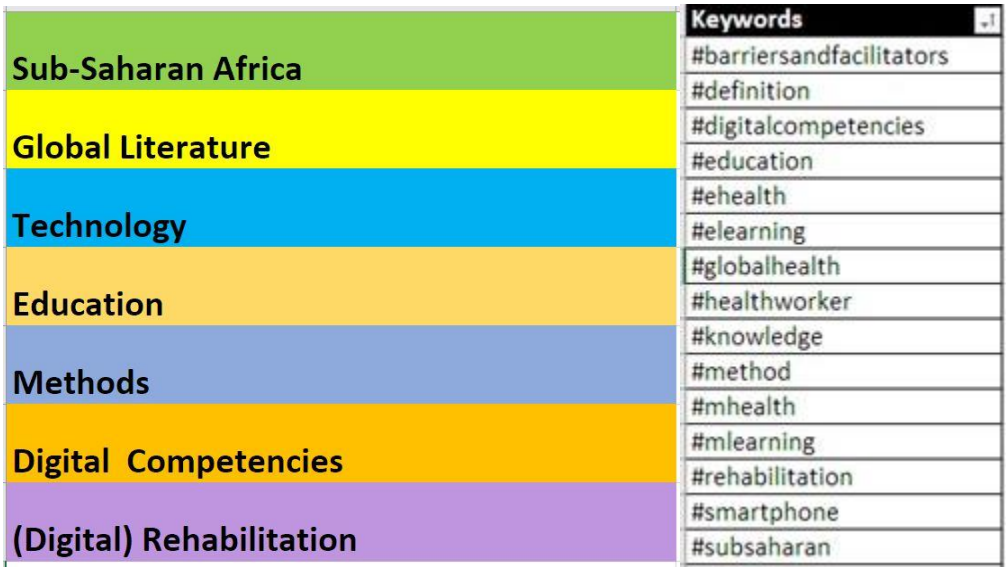


Figure 10: Self-defined research areas and keywords resulting from the literature screening. Own illustration.

3.2.2 Development and distribution of the questionnaire

Based on the information of the literature research and the results of a group discussion on the future perspectives regarding digital technologies with the African Partners of the Erasmus+ project *Competences for the new era of user-driven digital rehabilitation* (DIRENE)[3] at the Learning, Teaching, Training Activities -Meeting in September 2021, a mixed methods questionnaire was developed for working and aspiring health professionals in sub-Saharan Africa.

The questionnaire was used to explore the needs of health professionals in sub-Saharan Africa for mobile learning on digital rehabilitation. The survey was guided by the questions (1) whether they have used or heard about online tools for further/basic education in the health sector, (2) what type of tool they have used/heard about, and (3) what barriers and facilitators they have experienced/heard about.

Excluding informed consent, the questionnaire consists of 32 questions, of which 27 questions are self-designed. In addition, questionnaires on similar topics were searched for appropriate questions and wording. For this purpose, the Agency for Healthcare Research and Quality database[4] was utilized. Three questionnaires were found that contained helpful questions. Of these, one question was taken literally, and four questions were modified. From the questionnaire “Engaging Diverse Patients in Health Information Technology Use” (*Engaging Diverse Patients in Health Information Technology Use | Digital Healthcare Research*, n.d.), question 43 was taken literally for Q10, and question 19 was modified for Q14. From the questionnaire “Use of Web-Based Health Information – For Patient Practice Portal Non-Users” (*Use of Web-Based Health Information – for Patient Practice Portal Non-Users*, n.d.), the questions 12 and 21 were modified for Q11 and Q20. Question five from the questionnaire “NYC REACH Regional Extension Center Provider Survey” (*NYC REACH Regional Extension Center Provider Survey*, n.d.) was modified for Q16. The coding of the questions of the developed questionnaire is attached in Appendix C.

The questionnaire included 18 single-choice questions. Two of these single-choice questions included sub-questions. Q11 included four sub-questions and had to be answered by indicating on a Likert scale from zero to five how strongly he or she agrees or disagrees with a statement. The response options *Strongly Disagree*,

[3] https://research.fhstp.ac.at/projekte/direne-aufbau-von-kompetenzen-und-faehigkeiten-fuer-eine-neue-aera-der-personenzentrierten-und-mobil-gesteuerten-digitalen-rehabilitation

[4] https://digital.ahrq.gov/document-type/questionnaire-survey

Disagree, *Agree,* and *Strongly Agree*, were given. Q16 included 16 sub-questions asking respondents to indicate how useful they found each of the listed features for mobile learning on digital rehabilitation. A four-point Likert scale from one to four was given with the response options *Not at all useful*, *Slightly useful*, *Useful,* and *Very Useful*, as well as the additional answer option *Not Important*. Both Likert scales were numbered to create the impression that the categories are equally spaced. An even number of response options was purposely used, as this meant that participants had to decide on a tendency.

In addition, five multiple-choice questions were asked, in which one or more answers from a predetermined set of choices had to be selected. To have the possibility to give another answer than the ones selected, the respondent had the option to choose other and write down his or her own answer. Once a participant selected other, it was required to enter an answer in the free text field. This applied to all multiple-choice questions and almost all single-choice questions. Single-choice questions asking the participant, for example, if he or she is a working professional, did not provide the option to answer other.

There were also nine open-ended questions. However, three of these asked for demographic data, with one question asking for participant age and the other two asking about the years of work and teaching experience. The other six open-ended questions were asked to get a deeper insight into the topic of barriers and facilitators of mobile learning in sub-Saharan Africa and perhaps identify issues that have not yet been described in the literature.

Except for four open-ended questions about additional barriers or facilitators that participants could imagine (Q12a, Q13a, Q17, and Q18), questions always had to be answered to move on to the next question.

The questions were grouped into four groups, and in the online survey, each group was presented to the participants coherently. The question groups are (1) personal background with five questions, (2) professional background with a maximum of 12 questions depending on the professional background of the participant, (3) mobile learning for basic and further education of health professionals in sub-Saharan Africa with eight questions, and (4) mobile learning to educate working and aspiring health professionals in sub-Saharan Africa on digital rehabilitation with seven questions. For the evaluation, question groups three and four were further divided into two subgroups. The four groups of questions with the respective subgroups are shown in Figure 11. Question groups one and two and the subgroups 3.1, 3.2, 4.1, and 4.2 formed the evaluation categories (see Table 4).

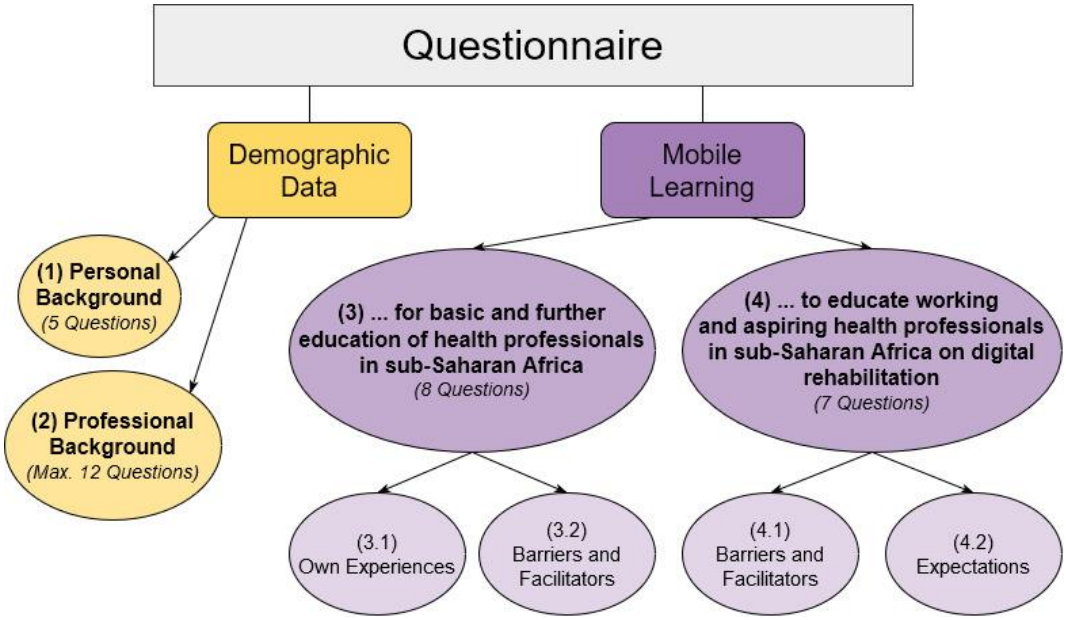


Figure 11: Grouping of questions in the questionnaire. Own illustration.

The questionnaire and a detailed flow of the questionnaire are attached (see Appendix 0 and Appendix E).

The survey took the participants about 15 minutes to complete and was accessible via a web browser on computers, tablets, and smartphones.

The link to the questionnaire was sent to multipliers and health professionals, including the African partners from the Erasmus+ project DIRENE. After one week, a reminder was sent to the African partners of the DIRENE project. The author also used her contacts and contacts of friends with Kenyan, Ghanaian, South African, and Gambian health professionals, as well as with the International Committee of the Red Cross. In addition, medical science colleges and universities, as well as therapy facilities that appear on Google Maps, have a website, and an email address were contacted by the author via email. Furthermore, the link to the survey was shared in relevant groups on social media. All approaches followed the snowball principle to recruit participants. The survey took place from the 10th of January 2022 to the 14th of March 2022.

3.2.3 Participants

Subjects of the survey were working and aspiring health professionals from sub-Saharan Africa. All participants had to be of legal age (at least 18 years old), working in a health profession, or be enrolled in a course or program of study for a health profession. In addition, they had to hold citizenship and/or have their center life in one of the countries in sub-Saharan Africa. These inclusion criteria were applied to include only individuals familiar with healthcare in sub-Saharan Africa to obtain relevant results. No further exclusion criteria were applied. In consultation with the author‘s supervisors, a sample size of 20 participants was considered meaningful. Like the survey, the recruitment took place from the 10th of January 2022 to the 14th of March 2022.

At the beginning of the survey, participants were informed of the study's nature, scope, and significance (see Appendix F), and informed consent was obtained. The respondents were aware that they were free to withdraw from the study at any time without personal disadvantage. There was no potential harm or risk to subjects from a medical point of view during data collection.

Data collection and processing were done with commercial software and all data obtained were stored on a local computer to which only the author had access. Only anonymized data may be used within the Erasmus+ project DIRENE. No data was passed on to third parties.

To ensure anonymization of the data, personal data (e.g., age, gender, citizenship / center of life, and occupation/profession) was collected in a format that does not allow any conclusions to be drawn about the identity. The IP address was only used to filter out multiple votes, for example, in the event of technical problems, so that no votes are counted twice. Literal quotations in the master thesis were additionally checked for anonymity to ensure that no conclusions about the respective persons are possible. If a person did not agree to the informed consent, the survey was terminated, and no data was collected.

This study works towards the Erasmus+ project DIRENE (2020-1-FI01-KA226-HE-092634) by exploring the needs of working and aspiring health professionals from sub-Saharan Africa in mobile learning on digital rehabilitation. The ethics committee of the Federal State Lower Austria has stated that there is no obligation for this study or the DIRENE project to be submitted to an ethics committee (GS1-EK-4/776-2022).

3.2.4 Evaluation of the results of the survey

Only participants who agreed to the informed consent and fully completed the questionnaire were included in the analysis of demographic data and the needs on mobile learning. These participants formed the study's research sample.

For a better overview and presentation of the results, open-ended and closed questions were assigned to one evaluation category (see Table 4).

Table 4: Questions of the questionnaire assigned to the evaluation categories. Own illustration.

Questions	**Question group**	**Evaluation category**
Q0	-	Informed consent
Q1 – 5	1	Personal background
Q6 – 8c	2	Professional background
Q9 – 10	3.1	Own experiences with mobile learning *for basic and further education* for health professionals in sub-Saharan Africa
Q11 – Q13a	3.2	Barriers and facilitators to mobile learning *for basic and further education* for health professionals in sub-Saharan Africa
Q14 + 16 (item 3, 4, 10, 11, 15, 16), Q17 + 18	4.1	Barriers and facilitators to mobile learning to educate working and aspiring health professionals in sub-Saharan Africa *on digital rehabilitation*
Q15 + 16 (item 1, 2, 5, 6, 7, 8, 9, 12, 13, 14), Q19 + 20	4.2	Expectations for mobile learning to educate working and aspiring health professionals in sub-Saharan Africa *on digital rehabilitation*

These categories correspond to the question group 1 and 2 and the subgroups 3.1, 3.2, 4.1, and 4.2 described in chapter 3.2.2. Table 4 provides an overview of the evaluation categories, the number of the corresponding question group, and the associated questions. For question Q16, parts of the sub-questions were assigned to the evaluation category expectations for educating working and aspiring health professionals in sub-Saharan Africa and another part to the evaluation category barriers and facilitators to mobile learning for health professionals in sub-Saharan Africa on digital rehabilitation.

The qualitative data obtained from the six open-ended questions was evaluated with the deductive, content structuring qualitative content analysis according to Mayring (2015). The literature research served as the basis for the deductive category formation. A code was created for each answer given by a participant. It is composed of the participant's ID, their role (E = Educator, L= Learners, L&E = Learner and Educator), and the number of the question to which the answer was given. For example: ID 5, E, Q12. The assignment of participants to their roles is explained later in this chapter. The answers to the open questions were assigned to the deductively created categories and the number of mentions was counted. Statements that were not assignable were presented individually or, in the case of an accumulation of similar statements, an additional category was identified.

For the analysis of the quantitative data, a descriptive analysis was performed. In evaluating the demographic data, the mean and standard deviation (SD) were calculated for each cardinal scaled variable. These are age, work experience, and teaching experience in years. All other questions about demographic data and mobile learning needs created nominally or ordinally scaled variables. For each variable in the evaluation categories personal and professional background, the absolute and relative frequencies were calculated, and the respective mode was highlighted. For the variables from the remaining four evaluation categories on mobile learning, the relative frequency of each response was calculated and compared between the learner and educator subgroups. Although both Likert scales were numbered with equal spacing to create the impression that the categories are equally spaced, it is not possible to generally assume that the respondent perceives the spacing of the individual response options as equally spaced. Therefore, no numerical evaluation was performed.

The results of the qualitative and quantitative data obtained were evaluated together in the evaluation categories.

In a first step, the personal background was analyzed once for all participants. In the second step, the participants were divided into the subgroups of *aspiring health professionals* and *working health professionals*, and a second analysis of the personal background and the professional background of these subgroups was performed. The third step consisted of the analysis of the data collected on the needs regarding mobile learning using all evaluation categories, including personal and professional background. For this, participants were assigned to a subgroup *learner*, subgroup *educator*, or *both subgroups*. Figure 12 illustrates the three steps and the assignment of participants to the subgroups.

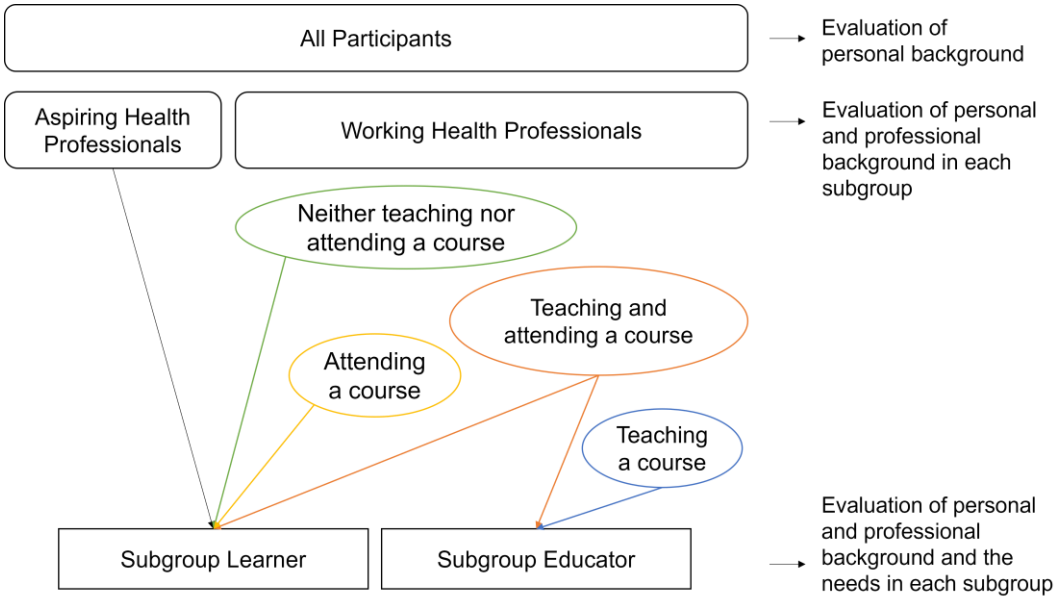


Figure 12: Assignment of the participants to the subgroups and the data analysis. Own illustration.

Aspiring health professionals and working health professionals who attended a course were assigned to the *learner* subgroup. Working professionals who were not attending or teaching a course at the time of the survey were also classified as *learners* because they are more likely to be potential learners. Working health professionals who reported teaching a course were classified as *educators* because it is assumed that their experience as educators affects their responses in the survey. Assignment to *both subgroups* was made for participants who were both learners and educators, since it is not possible for them to answer the questionnaire from the perspective of only one role. This case was applied to working health professionals who reported attending and teaching a course.

Therefore, it was decided that the answers of these participants were included twice in the evaluation. Due to the double use of responses, the number of counted responses in the subgroup educator and learner may exceed the number of participants in the survey.

By this classification, all participants except working health professionals who are also educators were assigned to the subgroup *learner*. The teaching health professionals were additionally analyzed in their role as *educators*.

Since only fully completed questionnaires were included in the analysis, and because of the additional requirement that each question had to be answered before moving on to the next, missing data in the data set was not possible.

3.3 Development of a digital guidebook

The goal of the digital guidebook is to show educators what to consider when creating a mobile learning unit on digital rehabilitation for health professionals in sub-Saharan Africa. Therefore, the target audience is educators who want to impart knowledge about digital rehabilitation to health professionals in sub-Saharan Africa.

Since videos and interactive elements are useful for learning (Alam et al., 2016; Barteit et al., 2018; Hew & Lo, 2018), the digital guidebook was designed as an interactive learning video. Mayer and Moreno (2002) did a review on multimedia learning, which includes, for example, narrated animations. This review focused on how animation in multimedia learning should be presented for educational purposes. They have summarized their findings in seven principles (see Table 5). Further, stories are a more efficient way to present content than just conveying facts because they are more remembered (Aaker & Aaker, 2016). Therefore, the content is presented as a story, and Mayer and Moreno's seven principles were applied to create the interactive learning video to facilitate effective learning.

To help viewers to better identify with the person in the video, the story is told from the point of view of a person who represents the target audience. For this, a persona was created that represents the target audience. The results of the educators' demographic data from the online survey were considered in its creation.

Table 5: Seven principles of animation in multimedia learning (Mayer & Moreno, 2002, pp. 93–97). Own illustration.

"Students learn more deeply…
(1) ...from animation and narration than from narration alone."
(2) ...when on-screen text is presented next to the portion of the animation that it describes than when on-screen text is presented far from the corresponding action in the animation."
(3) ...when corresponding portions of the narration and animation are presented at the same time than when they are separated in time."
(4) ...from animation and narration when extraneous words, sounds (including music), and video are excluded rather than included."
(5) ...from animation and narration than from animation and on-screen text."
(6) ...from animation and narration than from animation, narration, and on-screen text."
(7) ...from animation and narration when the narration is in conversational rather than formal style."

To develop the story for the video, a storyline was created. Afterward, a storyboard and the text for the video were created in parallel. The storyboard included the text for the voiceover and the action for each frame. Further, it outlined the timing of interactive elements. The content of the interactive learning video is based on the survey's main findings and relevant findings from the literature research.

In a first step, the premium version of Vyond[5], an online animation software, was used to create the video. If images were needed for the video creation but were not included in the software, they were uploaded additionally. Hereby, only images released under the Creative Common License and allowed to be reused without any attribution were uploaded. The platform's text-to-speech feature was used for the speech in the video. The video was then divided into shorter video clips, and a short summary of the previous clip was inserted at the beginning of each video clip. Copyright notice and the frame in which the video was created were added to the end of each video clip. The four video clips were downloaded on a local computer

[5] https://www.vyond.com/

in mp4 format. In a second step, H5P[6], a software for creating interactive learning content, was used to add interactive elements to each video clip. For this purpose, a plugin was installed on a website created with the open-source content management system WordPress[7] that runs on the webserver of St. Pölten University of Applied Sciences. The four video clips were uploaded to the website, and interactive elements were added. In the end, the interactive video clips in hp5 format were downloaded on a local computer and uploaded to Lumi[8], another open-source software that allows videos with H5P content to be converted into hypertext markup language (HTML) files. Since HTML files run in a web browser without an Internet connection or learning management system, the viewer can go through the interactive video offline. The conversion also allows the video to be freely shared. These programs were identified through the Google search engine. In addition, the author's supervisors provided links to potentially useful software.

[6] https://h5p.org/

[7] https://wordpress.com/de/

[8] https://lumi.education/

4 Results

The following chapters present the results of the literature research as well as the empirical quantitative and qualitative results from the online survey. The empirical data includes demographic data with the personal and professional background of all participants as well as the subgroups, along with the results of the closed and open-ended questions on the needs regarding mobile learning for learners and educators, grouped into the evaluation categories (see Table 4). Further, the content and design of the developed interactive learning video are presented.

4.1 Literature research

After removing duplicates, the *comprehensive systematized review of the literature* resulted in a total of 239 hits on the first topic, which is the effectiveness of existing mobile learning opportunities to improve the knowledge and skills of working and aspiring health professionals in sub-Saharan Africa. The 239 hits represent the sum of the final results of the queries in the database PubMed and in the JMIR database. The first query in the database PubMed of the NICB using the keywords and Boolean operators described in chapter 3.2.1 resulted in six hits from 2015 to 2021. Combining only the keyword groups of effectiveness, mobile learning, health workforce, and sub-Saharan Africa, the second query results in a total of ten hits from 2014 to 2021. However, these ten hits include the six hits from the first query. The query in the JMIR database resulted in 229 hits.

The *comprehensive systematized review of the literature* on the second topic, the barriers and facilitators of mobile learning in sub-Saharan Africa for health professionals, resulted in a total of 52 hits after duplicates were removed. The 52 hits represent the sum of the final results of the queries in the database PubMed and in the JMIR database. The first query in the database PubMed of the NCIB using the keywords and Boolean operators described in chapter 3.2.1 resulted in zero hits. Leaving out the keyword group health professionals, the search resulted in 31 hits from 2008 to 2021. The query in the JMIR database for the second topic resulted in 2138 hits. With a filter, which only displays the journal JMIR Medical Education, the number of hits was reduced to 21.

The findings of these two *comprehensive systematized reviews* are described in the theory section in chapter 2.6.

4.2 Online survey

A total of 21 people opened the survey. Of these, 19 agreed to the informed consent, one person did not answer the question, and one person did not go further than the welcome page, which means that the informed consent was not displayed to him or her. Of the 19 people who agreed to informed consent, 13 completed the survey in full.

The results of the questions in each evaluation category are presented in the following chapters.

4.2.1 Demographic characteristics of the participants

The demographic characteristics were asked in the evaluation categories (1) personal background and (2) professional background and were analyzed once for the entire sample and once for each subgroup. All participants were working health professionals, and since no aspiring health professionals participated, the demographic characteristics of all participants were represented by the subgroup of working health professionals. Therefore, the analysis of the demographic data of the subgroups of aspiring and working health professionals was omitted.

To evaluate the demographic characteristics of educators and learners, the participants were assigned to the subgroups learner and educator as described previously. As presented in Figure 13, two of the five educators who completed the survey were assigned to the educator's subgroup and learner's subgroup because they attended a course as well. The remaining three educators were assigned to the subgroup educator. This resulted in a double evaluation of two responses. Thus, the total number of counted responses in the two subgroups exceeded the number of participants in the survey by two. The eight working health professionals who did not report being educators were assigned to the subgroup learner. This assignment resulted in ten responses for the learner subgroup and five for the educator subgroup. The personal and professional background of the participant in each subgroup is shown in Table 6 and Table 7.

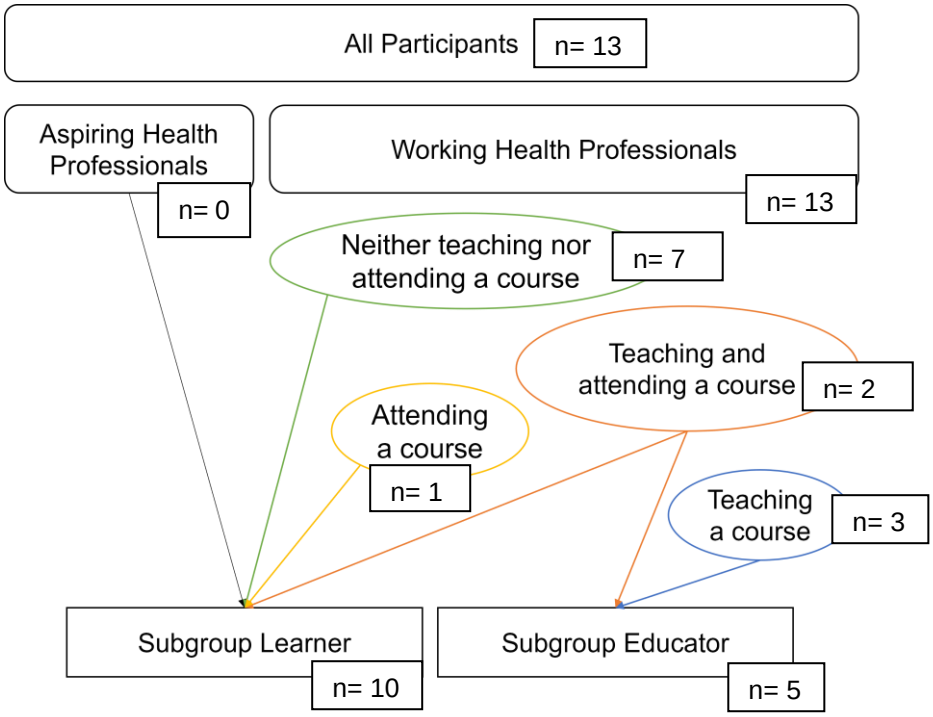


Figure 13: Number of study participants from each professional background and their assignment to the two subgroups learner and educator. Own illustration.

(1) Personal Background

Thirteen working health professionals and zero aspiring health professionals participated in the survey. Of these working health professionals, five were also educators and three attended a course. Of the three course attendees, two were also educators.

The average age of the participants was 40 years (SD 13). The mean age of the educators was 46 years (SD 14), and the mean age of the learners was 36 years (SD 11). The SDs show a wide distribution in both groups. Men and women were evenly represented in the educator and learner subgroups, with 60% women and 40% men. With 46%, most participants reported a bachelor's degree as their highest level of education, followed by 31% with a diploma. After the assignment to a subgroup of educators or learners, 80% of the learner's subgroup consisted of bachelor's or diploma graduates. In the educator subgroup, the percentage was only 40%. Here, the proportion of master's and doctoral degrees was highest at 60%. Four participants were from Ghana in West-Africa, three from South Africa, and the remaining six participants were from East-Africa. Both subgroups included participants from East-, West-, and South-Africa.

Table 6: Personal background of the participants of the online survey in the subgroups of working health professionals, learners, and educators, where the working health professionals also represent the whole sample. | SD = standard deviation, n = absolute frequency, % = relative frequency | All numbers rounded to a whole number. Own illustration.

Personal Background

Characteristics	**Working Health Professionals** (n=13)	**Subgroup Learner** (n=10)	**Subgroup Educator** (n=5)
Age in years [Mean (SD)]	40 (13)	36 (11)	46 (14)
Gender [n (%)]			
Women	7 (54%)	6 (60%)	3 (60%)
Men	6 (46%)	4 (40%)	2 (40%)
Highest educational qualification [n (%)]			
Student	0 (0%)	0 (0%)	0 (0%)
Assistant	0 (0%)	0 (0%)	0 (0%)
Diploma	4 (31%)	3 (30%)	1 (20%)
Bachelor's degree	6 (46%)	5 (50%)	1 (20%)
Master's degree	2 (15%)	1 (10%)	2 (40%)
Doctor's degree	1 (8%)	1 (10%)	1 (20%)
Others	0 (0%)	0 (0%)	0 (0%)
Citizenship or the center of life in a sub-Saharan country [n (%)]			
Citizenship	7 (54%)	5 (50%)	2 (40%)
Center of life	0 (0%)	0 (0%)	0 (0%)
Both	6 (46%)	5 (50%)	3 (60%)
Country of Citizenship / Center of life [n (%)]			
Ghana	4 (31%)	3 (30%)	1 (20%)
Rwanda	3 (23%)	3 (30%)	1 (20%)
Kenya	2 (15%)	2 (20%)	0 (0%)
South Africa	3 (23%)	2 (20%)	2 (40%)
Tanzania	1 (8%)	0 (0%)	1 (20%)

(2) Professional Background

With five participants from physiotherapy, this professional group was most strongly represented in the survey, followed by nurses with three participants. Two participants each came from occupational therapy and orthoptics, as well as one physician. Except for nursing participants, all professional groups were evenly distributed between the two subgroups of educators and learners.

The mean work experience of all participants was 15 years (SD 15). Again, with a mean of 20 years of work experience (SD 16), the mean is higher for the subgroup of educators than for the subgroup of learners, with a mean of 12 years of working experience (SD 12). Similar to the age of the participants, the SDs in both

subgroups show a large dispersion. Eight participants reported having a leading position. Their answers were evenly distributed in the subgroups, with 60% in a leading position and 40% not.

In the sample, 54% of participants worked in an urban area, 23% worked in rural areas, and 23% worked in urban and rural areas. Therefore, the sample had more working experience in the urban area. With 70% of learners who worked in an urban area and 30% who worked in a rural area, participants in this subgroup had more experience working in urban areas, which is similar to the study sample. However, only 20% of the educators worked in the urban area and 20% in the rural area. The remaining 60% worked in both urban and rural areas, thus they had more work experience in rural areas than the learner subgroup.

Three of the participants were enrolled in a degree program, and two of them were also educators. Since two of them were both educators and course attendees, there was a reasonably even distribution of course attendee responses among the subgroups, with 30% in the learner subgroup and 40% in the educator subgroup.

Out of the five educators in the sample, three reported teaching occupational therapists. Physiotherapists and orthopedic technicians were each mentioned twice. Other professions mentioned once were radiologists, speech therapists, physiotherapy assistants, and biomedical engineering students. The average working experience as an educator was 14 years (SD 15).

Table 7: Professional background of the participants of the online survey in the subgroups of working health professionals, learners, and educators, where the working health professionals also represent the whole sample. | SD = standard deviation, n = absolute frequency, % = relative frequency | n/a = not available | All numbers rounded to a whole number. Own illustration.

Professional Background

Characteristics	**Working Health Professionals** (n=13)	**Subgroup Learner** (n=10)	**Subgroup Educator** (n=5)
Working professional [n (%)]			
Yes	13 (100%)	10 (100%)	5 (100%)
No	0 (0%)	0 (0%)	0 (0%)
Profession [n (%)]			
Physiotherapist	5 (39%)	4 (40%)	2 (40%)
Nurse	3 (23%)	3 (30%)	0 (0%)
Physician	1 (8%)	1 (10%)	1 (20%)
Occupational Therapist	2 (15%)	1 (10%)	1 (20%)
Orthoptist	2 (15%)	1 (10%)	1 (20%)
Years of working experiences [Mean (SD)]	15 (15)	12 (12)	20 (16)

Leading position [n (%)]			
Yes	8 (62%)	6 (60%)	3 (60%)
No	5 (38%)	4 (40%)	2 (40%)
Working area [n (%)]			
Rural	3 (23%)	3 (30%)	1 (20%)
Urban	7 (54%)	7 (70%)	1 (20%)
Both	3 (23%)	0 (0%)	3 (60%)
Enrolled in a study program [n (%)]			
Yes	3 (23%)	3 (30%)	2 (40%)
No	10 (77%)	7 (70%)	3 (60%)
Expected degree [n (%)]			
Assistant	0 (0%)	0 (0%)	0 (0%)
Diploma	1 (8%)	1 (10%)	1 (20%)
Bachelor's degree	1 (8%)	1 (10%)	0 (0%)
Master's degree	0 (0%)	0 (0%)	0 (0%)
Doctor's degree	1 (8%)	1 (10%)	1 (20%)
Others	0 (0%)	0 (0%)	0 (0%)
Medical field [n (%)]			
Physiotherapy	2 (15%)	2 (20%)	1 (20%)
Human Medicine	1 (8%)	1 (10%)	1 (20%)
Educator [n (%)]			
Yes	5 (38%)	2 (20%)	5 (100%)
No	8 (62%)	8 (80%)	0 (0%)
Professions taught [n]			
Physiotherapists	n/a	n/a	2
Radiologists			1
Speech Therapists			1
Occupational Therapists			3
Orthopedic Technicians			2
Physiotherapy Assistants			1
Others:			3
Biomedical Engineering Students			1
Students			1
Registrats			1
Educational level taught [n]			
Assistant	n/a	n/a	1
Diploma			2
Bachelor's degree			1
Master's degree			0
Doctor's degree			2
Others:			2
Higher National Diploma (HND)			1
Continuous Professional Development - Certificate			1
Years of experience as an educator [Mean (SD)]	n/a	n/a	14 (15)

4.2.2 Needs regarding mobile learning

The following part presents the results of the four evaluation categories regarding the needs on mobile learning in basic and further education as well as mobile learning on digital rehabilitation for each subgroup of educators and learners.

(3.1) Own experiences with mobile learning for basic and further education for health professionals in sub-Saharan Africa

While half of the learners had never heard or read about mobile learning, only 20% of educators were unaware of basic or further training for health professionals in sub-Saharan Africa through mobile learning. Of the remaining 80% of educators, half have already used mobile learning themselves, and the other half have heard or read about it. Among learners, only 20% have already used mobile learning themselves. The remaining 30% have heard or read about offers in their country (see Figure 14).

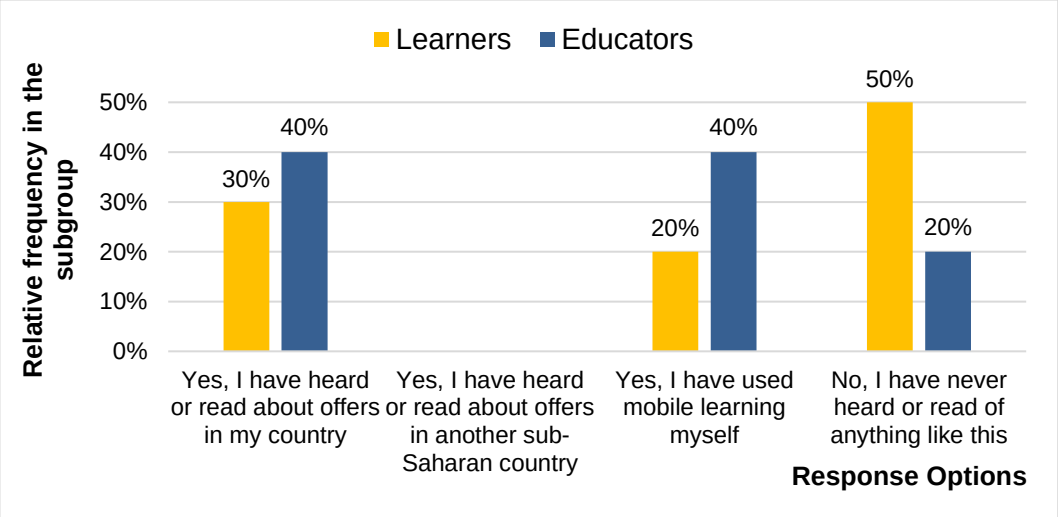


Figure 14: Comparison of the relative frequencies of participants' previous experiences with mobile learning for basic and further education for health professionals between the learner and educator subgroups. Own illustration.

Educators and learners who reported using, hearing about, or reading about such a program were asked in an open-ended question which mobile learning program(s) they had used, heard about, or read about (see Table 8). In terms of channels and technologies, two learners and one educator mentioned video conferencing. In contrast, two educators and one learner mentioned learning platforms. Instant messengers were stated by one educator and one learner. Social media was not mentioned at all. For learning platforms, Cybersight was mentioned most often, and for instant messengers, WhatsApp was mentioned most often, followed by Telegram, mentioned once. Zoom was mentioned most

often as a video conferencing tool, followed by MS Teams and Skype each mentioned once. One learner reported using "… *Zoom, telegram [sic] messenger and whats app [sic] messenger…*" (ID 13, L), and one of the educators mentioned "*online training programs, zoom conferences and WhatsApp, distance learning & skype…*" (ID 21, E). The subcategory 1.4 Learning platforms was subsequently added, as it was mentioned multiple times. Various healthcare areas were mentioned in the responses. These are nursing, cancer, speech, and malnutrition. Each area was mentioned once. In addition, two learners and one educator reported using these technologies to discuss different topics. One learner reported attending lectures and presentations.

Table 8: Results of the upper category *Mobile learning programs* and its subcategories from the qualitative evaluation | UC = Upper Category, SC = Subcategory. Own illustration.

Category	Definition	Number of mentions	Codes & Content
UC 1: Mobile learning programs	Mobile learning programs used by working and aspiring health professionals or that they have heard about or read about to further their education or receive basic education in sub-Saharan Africa	8	-
SC 1.1: Social media	Social media channels used by working and aspiring health professionals or that they have heard about or read about to further their education or receive basic education in sub-Saharan Africa	0	-
SC 1.2: Instant messenger	Instant messengers used by working and aspiring health professionals or that they have heard about or read about to further their education or receive basic education in sub-Saharan Africa	2	ID 13, L, Q9a ID 21, E, Q9a WhatsApp 2x Telegram 1x
SC 1.3: Video conferences	Options for video conferences used by working and aspiring health professionals or that they have heard about or read about to further their education or receive basic education in sub-Saharan Africa	3	ID 13, L, Q9a ID 28, L, Q9a ID 21, E, Q9a Zoom 3x MS Teams 1x Skype 1x
New: SC 1.4 Learning platforms	Learning platforms used by working and aspiring health professionals or that they have heard about or read about to further their education or receive basic education in sub-Saharan Africa	3	ID 28, L, Q9a ID 21, E, Q9a ID 27, E, Q9a Cybersight 2x Online training program 1x

Although 70% of respondents reported never having heard or read about mobile learning, only 10% indicated that they had not expanded their knowledge through any of the proposed technologies in the past 12 months (see Figure 15). For learning, most educators (80%) indicated using video conferencing, and learners mainly reported using apps on smartphones or mobile devices (60%). The second most common technology stated by educators was also apps and additionally email (each 60%). The second most common use reported by learners was social media (50%). Participants in both subgroups selected the answer option other and indicated that an online course was taken to expand knowledge.

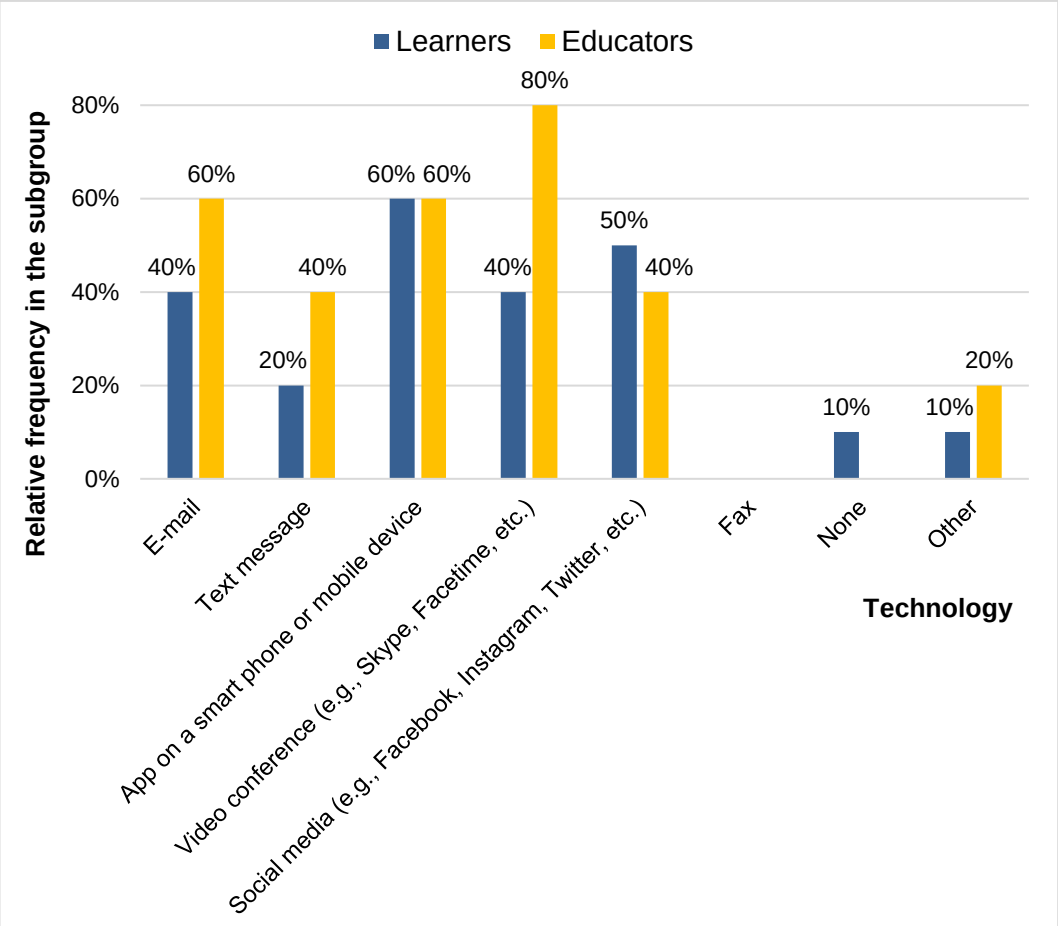


Figure 15: Comparison of the relative frequencies with which participants use certain technology to increase their knowledge of a topic related to their profession between the learner and educator subgroups. Multiple responses were possible for this question. Own illustration.

(3.2) Barriers and facilitators to mobile learning for basic and further education for health professionals in sub-Saharan Africa

The first question asked participants to what extent they agreed or disagreed with four statements about mobile learning (see Figure 16). The first sub-question showed that 70% of learners and all educators were not concerned about privacy in online courses. However, 30% of learners who were concerned about data privacy were very concerned. As for the cost, none of the educators had concerns, but 40% of the learners agreed or strongly agreed that a course might cost too much. Concerns about content quality were similar in both subgroups, with the majority of 80% of educators and 70% of learners having no concerns. In contrast, the answers in both subgroups were different when asked about their confidence in their ability to use a mobile phone for mobile learning. All educators strongly disagreed with the statement that they may not have the necessary skills. Of the learners, only 60% strongly disagreed with this statement, 20% disagreed, 10% agreed, and 10% strongly agreed.

Regarding barriers to mobile learning in basic and further education of health professionals in sub-Saharan Africa, educators (80%) and learners (70%) considered Internet connectivity to be the biggest barrier, while Internet quality and cost ranked second at 69% for both subgroups (see Figure 17). In contrast, only 20% in both subgroups consider access to a mobile device to be a barrier. Differences were found between subgroups in responses to the categories of technical support, language barrier, and electricity. No technical support was seen as a barrier by 40% of educators and only 10% of learners. In contrast, 40% of learners reported that the language barrier is a problem, which none of the educators stated. Electricity is a barrier for 40% of the learners, but only for 20% of the educators. 10% of learners indicated that courses held in other time zones are also a barrier.

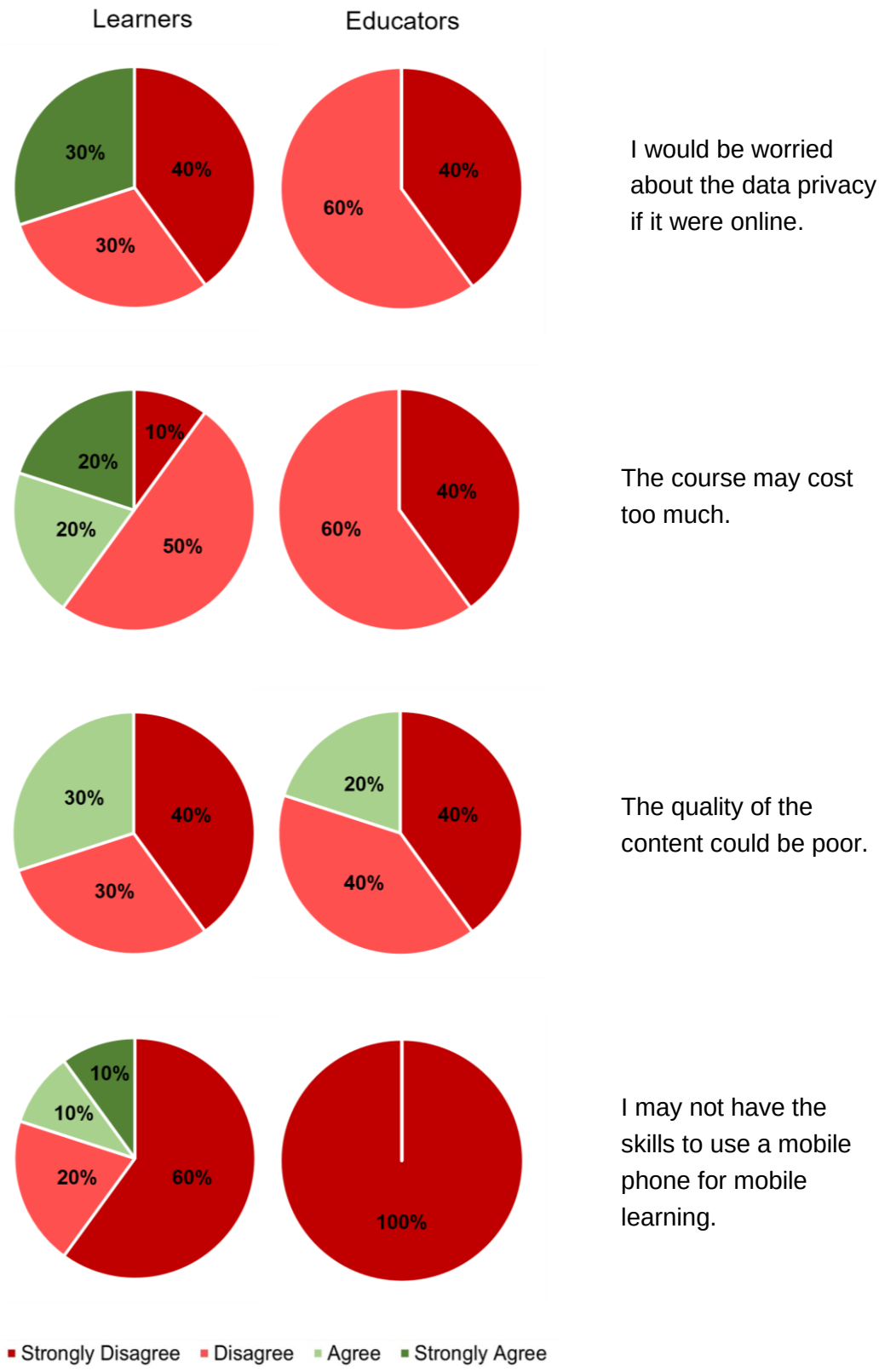


Figure 16: Comparison of the relative frequencies of agreement and disagreement to four statements between the subgroup's learners and educators on mobile learning in basic and further education of health professionals. Own illustration.

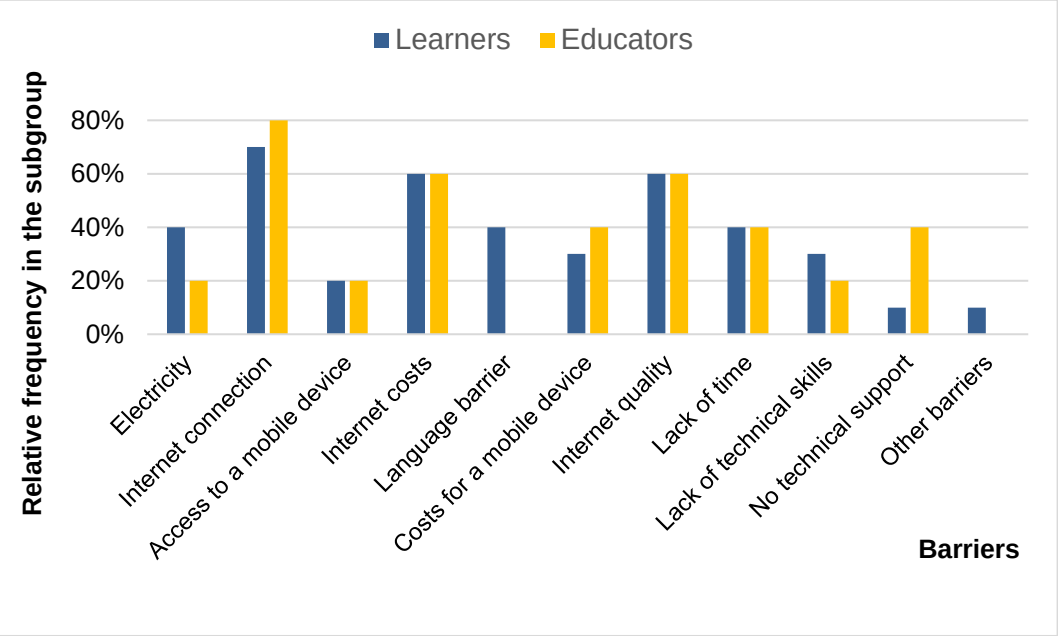


Figure 17: Comparison of the relative frequencies of selected response options on barriers to mobile learning for basic and further education of health professionals between learner and educator subgroups. Multiple responses were possible for this question. Own illustration.

Participants were also asked in an open-ended question if they could think of any other barriers than those mentioned before (see Table 9). Here, no one reported any further infrastructural barriers. Financial barriers were mentioned twice as well as individual barriers. In these subcategories, the cost of a laptop and the lack of a laptop were mentioned once as barriers. In this context, one of the participants stated that *"… It is uncomfortable to attend an hour long presentationona [sic] phone app" (*ID 28, L, Q12a). The second financial barrier mentioned once is paying for registration. Two responses did not match any subgroup. One of these reported, *"access to programs…"* (ID 21, E, Q12a) as another barrier. However, this could be due to financial as well as individual or infrastructural problems. The other person reported that *"Many health workers or students in health care courses are not aware of the amount of information they can get or share using mobile devices and tend to rely only on information in books and information from their lecturers"* (ID 13, L, Q12a). No differences or similarities were found between the subgroups of educators and learners. The answers did not result in a new subcategory.

Table 9: Results of the upper category *Barriers to mobile learning* and its subcategories from the qualitative evaluation. | UC = Upper Category, SC = Subcategory. Own illustration.

Category	Definition	Number of mentions	Codes & Content
UC 2: Barriers to mobile learning	Barriers that working and aspiring health professionals face in mobile learning to further their education or receive basic education in sub-Saharan Africa	4	-
SC 2.1: Individual barriers	Individual barriers that working and aspiring health professionals face	2	ID 22, L, Q12a ID 21, E, Q12a Lack of Laptop 1x Need to subscribe 1x
SC 2.2: Infrastructural barriers	Infrastructural barriers that working and aspiring health professionals face	0	-
SC 2.3: Financial barriers	Financial barriers that working and aspiring health professionals face.	2	ID 28, L, Q12a ID 21, E, Q12a Cost of laptop 1x Pay for registration 1x

For facilitators, offline content was ranked first by learners at 70%. For educators, three response options were ranked first with 60% each, including offline content (see Figure 18). The other two items were personal visits by a trained person to health professionals in their setting and the explanations of device use. However, only 20% of learners indicated that explanations of how to use the devices is a facilitator. Both subgroups indicated that using devices from family members or neighbors and subtitles in their native language were the least relevant. Using a university device is more of a facilitator for learners (40%) than for educators (20%).

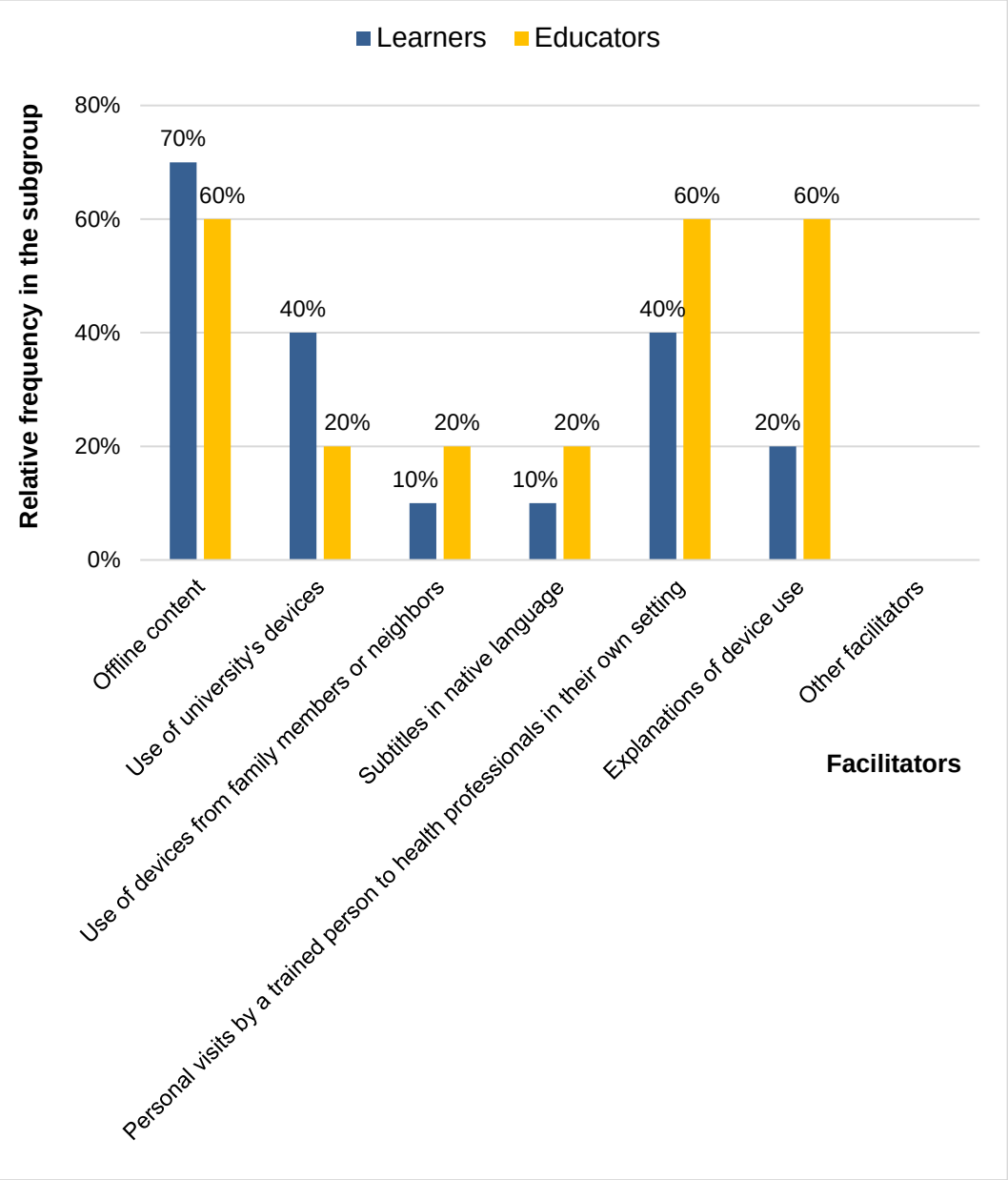


Figure 18: Comparison of the relative frequencies of selected response options on facilitators to mobile learning for basic and further education of health professionals between learner and educator subgroups. Multiple responses were possible for this question. Own illustration.

In response to the open-ended question about other facilitators, three of four subcategories were mentioned once (see Table 10). Regarding financial support, the availability of devices was mentioned once, and in terms of infrastructural facilitation, a good wi-fi connection. Chatbots were mentioned as a specific function, with the idea "*… to train some people on different services available in Digital Rehabilitation*" (ID 18, L&E, Q13a).

One answer was not assignable to one of the subcategories. Here, the answer was "*Senior work mates*" (ID 22, L, Q13a). The answers did not result in a new subcategory, and again, no differences or similarities between the subgroups of educators and learners were found in the results for this open-ended question.

Table 10: Results of the upper category *Facilitators to mobile learning* and its subcategories from the qualitative evaluation. | UC = Upper Category, SC = Subcategory. Own illustration.

Category	Definition	Number of mentions	Codes & Content
UC 3: Facilitators to mobile learning	Facilitators for working and aspiring health professionals in mobile learning to further their education or receive basic education in sub-Saharan Africa	3	-
SC 3.1: Financial support	Financial support options for working and aspiring health professionals to facilitate mobile learning	1	ID 19, L, Q13a Availability of devices 1x
SC 3.2: Technical support	Technical support options for working and aspiring health professionals to facilitate mobile learning	-	-
SC 3.3: Specific functions	Specific functions in mobile learning programs that facilitate mobile learning for working and aspiring health professionals	1	ID 18, L&E, Q13a Chat bots 1x
SC 3.4: Infrastructural facilitators	Aspects of infrastructure that facilitate mobile learning for working and aspiring health professionals	1	ID 19, L, Q13a Good wi-fi connection 1x

(4.1) Barriers and facilitators to mobile learning to educate working and aspiring health professionals in sub-Saharan Africa on digital rehabilitation

When asked where participants normally use a mobile device to access educational materials, all educators and 90% of the learners indicated that they access the information from home (see Figure 19). The educational institution was mentioned by 60% of educators and 50% of learners and therefore second most often in both subgroups. Further, 40% in both subgroups reported using the mobile device to access educational materials indoors, compared to only 20% outdoors. The answer option other was used here in both subgroups. In both subgroups, the answer option at work was added, and in the subgroup of educators, recreation places were additionally mentioned.

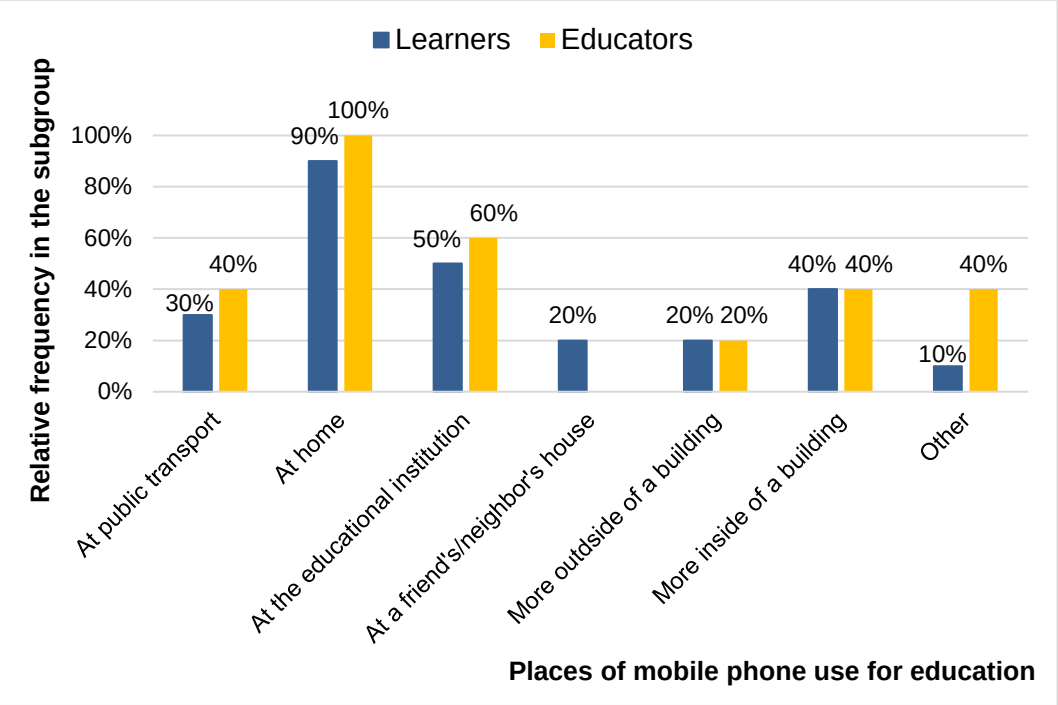


Figure 19: Comparison of the relative frequencies where participants use a mobile device to access educational materials between the learner and educator subgroups. Multiple responses were possible for this question. Own illustration.

Six sub-questions in question Q16, which asked participants to indicate how useful they rated a feature in a mobile learning course on digital rehabilitation, addressed the barriers and facilitators to mobile learning on digital rehabilitation. The remaining ten sub-questions in Q16 that address participants' expectations of mobile learning on digital rehabilitation are presented in the following subchapter.

All of the proposed features in the six barriers and facilitators sub-questions were rated as useful or very useful by at least 50% of participants in both subgroups. However, some features were rated better than others, and differences existed between the educator and learner subgroups (see Figure 20). Both subgroups preferred to save the progress made at any time rather than only after a submodule. The educators considered it even slightly more important than the learners. When choosing subtitles, both subgroups found subtitles in the language of the video, in this case, English, more useful than subtitles in their native language. Of the educators, as many as 20% indicated that subtitles in the native language are not useful at all. Overall, however, both subgroups rated subtitles in English and the native language as generally useful. With 80% in the educator subgroup and 70% in the learner subgroup, downloadable content received the highest rating of very useful in both subgroups. Playable text was rated as less useful by both educators and learners.

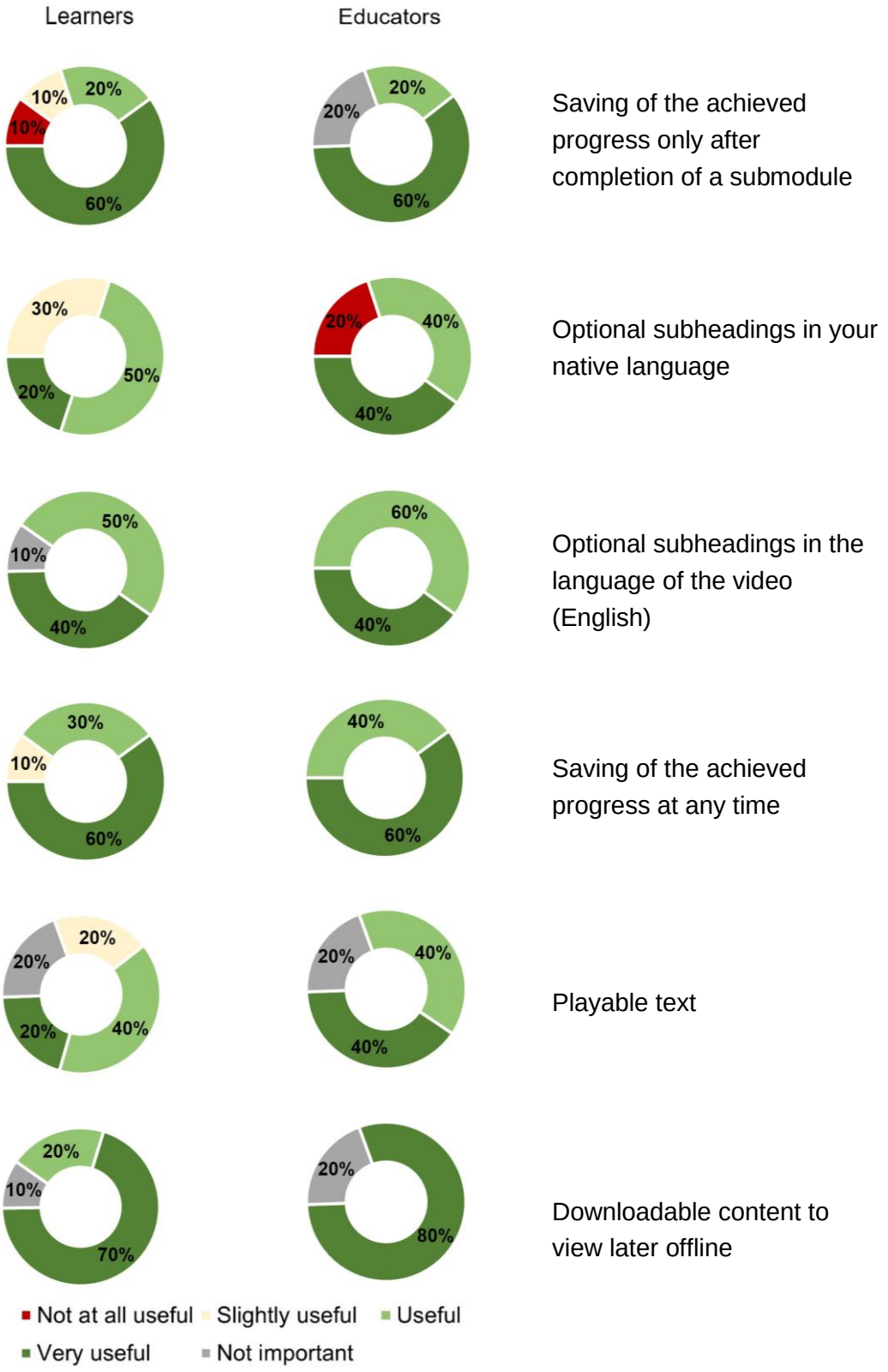


Figure 20: Comparison of the relative frequencies of perceived usefulness of six features regarding barriers and facilitators of mobile learning on digital rehabilitation between the subgroup's learners and educators. Own illustration.

When asked about other useful functions that might be especially useful for a mobile learning unit on digital rehabilitation, three mentions were made, all of which were assigned to the subcategory Specific functions (see Table 11). User-friendly font and *"Live sessions with interaction with the trainer…*" (ID 18, L&E, Q17) were mentioned once. Further, the "*Provision of certificate for download and future use*" (ID 19, L, Q17) was mentioned once. No other facilitators were mentioned in the subcategories Financial support, Technical support, and Infrastructural facilitators. No differences or similarities were found between the subgroups, and no new subcategory was created.

The open-ended question on barriers that might prevent someone from participating in a mobile learning unit on digital rehabilitation resulted in noticeably more mentions (see Table 12). There were a total of eleven mentions, of which six were assigned to the subcategory Individual barriers and four to the subcategory Infrastructural barriers. One mention was assigned to the subcategory of financial barriers. No time, "*Attitude and lack of interest*" (ID 19, L, Q18), *"… Lack or [sic] knowledge on how to operate mobile device…*" (ID 13, L, Q18), as well as accessibility to facilities and availability of a mobile device were mentioned by the participants within the subgroup Individual barriers. Regarding infrastructural barriers, all four mentions were related to the network or Internet connection. Here they named "*Poor network connection*" (ID 15, L, Q18), *"… network interruption…"* (ID 21, E, Q18), "*Lack of internet connection*" (ID 22, L, Q18), and "… *Bad internet…*" (ID 13, L, Q18). Internet costs was the aspect mentioned once as a financial barrier. One participant's response was not assignable to one of the subcategories. The person indicated that "*Lack of information or notices on time"* (ID 21, E, Q18) is another barrier. Both educators and learners mentioned networking problems. Furthermore, no similarities or differences between these two subgroups were identified. No new subcategory was created.

Table 11: Results of the upper category *Useful features for a mobile learning unit on digital rehabilitation* and its subcategories from the qualitative evaluation. | UC = Upper Category, SC = Subcategory. Own illustration.

Category	Definition	Number of mentions	Codes & Content
UC 4: Useful features for a mobile learning unit on digital rehabilitation	Useful features for a mobile learning unit on digital rehabilitation to educate working and aspiring health professionals in sub-Saharan Africa	3	-
SC 4.1: Financial support	Financial support options for working and aspiring health professionals to facilitate mobile learning on digital rehabilitation	0	-
SC 4.2: Technical support	Technical support options for working and aspiring health professionals to facilitate mobile learning on digital rehabilitation	0	-
SC 4.3: Specific functions	Specific functions in mobile learning programs that facilitate mobile learning for working and aspiring health professionals on digital rehabilitation	3	ID 19, L, Q17 ID 18, L&E, Q17 ID 21, E, Q17 Certificate 1x User friendly font 1x Live sessions with interaction with the trainer 1x
SC 4.4: Infrastructural facilitators	Aspects of infrastructure that facilitate mobile learning on digital rehabilitation for working and aspiring health professionals	0	-

Table 12: Results of the upper category *Barriers that prevent from participating in a mobile learning unit on digital rehabilitation* and its subcategories from the qualitative evaluation. | UC = Upper Category, SC = Subcategory. Own illustration.

Category	Definition	Number of mentions	Codes & Content
UC 5: Barriers that prevent from participating in a mobile learning unit on digital rehabilitation	Barriers that prevent a working or aspiring health professional in sub-Saharan Africa from participating in a mobile learning unit on digital rehabilitation	11	-
SC 5.1: Individual barriers	Individual barriers that health professionals face in a mobile learning unit on digital rehabilitation.	6	ID 13, L, Q18 ID 19, L, Q18 ID 18, L&E, Q18 ID 21, E, Q18 No time 1x Attitude 1x Lack of interest 1x Insufficient technical skills 1x Accessibility to facilities 1x Availability of mobile device 1x
SC 5.2: Infrastructural barriers	Infrastructural barriers that health professionals face in mobile learning on digital rehabilitation	4	ID 13, L, Q18 ID 15, L, Q18 ID 22, L, Q18 ID 21, E, Q18 Network / Internet problems 4x
SC 5.3: Financial barriers	Financial barriers that health professionals face in mobile learning on digital rehabilitation	1	ID 13, L, Q18 Internet costs 1x

(4.2) Expectations for mobile learning to educate working and aspiring health professionals in sub-Saharan Africa on digital rehabilitation

In terms of expectations for additional classroom lessons during a mobile learning course on digital rehabilitation, all educators and 70% of the learners indicated that they would like to have them (see Figure 21). However, educators and learners would like to see only optional, not mandatory, live classes. 30% of learners would prefer the course without additional classroom lessons. Regarding the length of the learning sessions, both subgroups reported that a mix of short and long sessions would be best (see Figure 22).

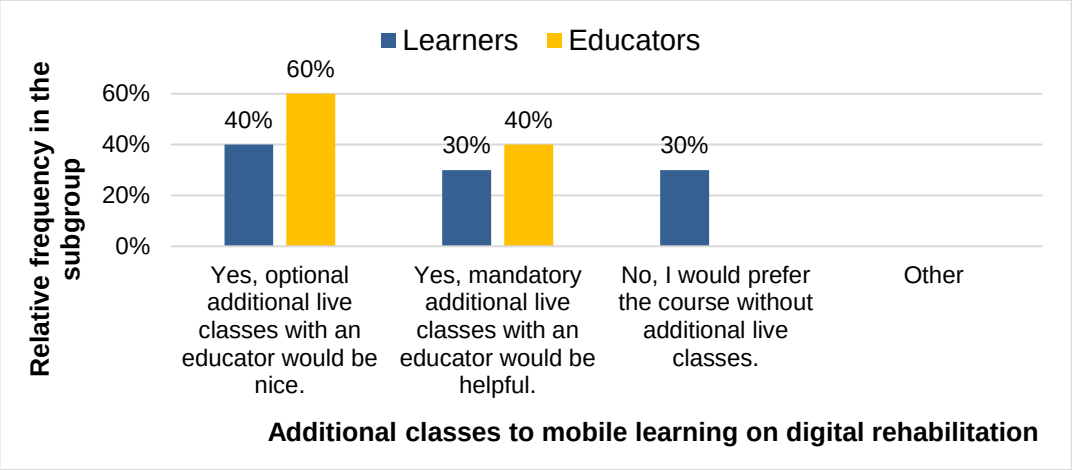


Figure 21: Comparison of the relative frequencies of the expectations for additional live sessions during a mobile learning course on digital rehabilitation between the learner and educator subgroups. Own illustration.

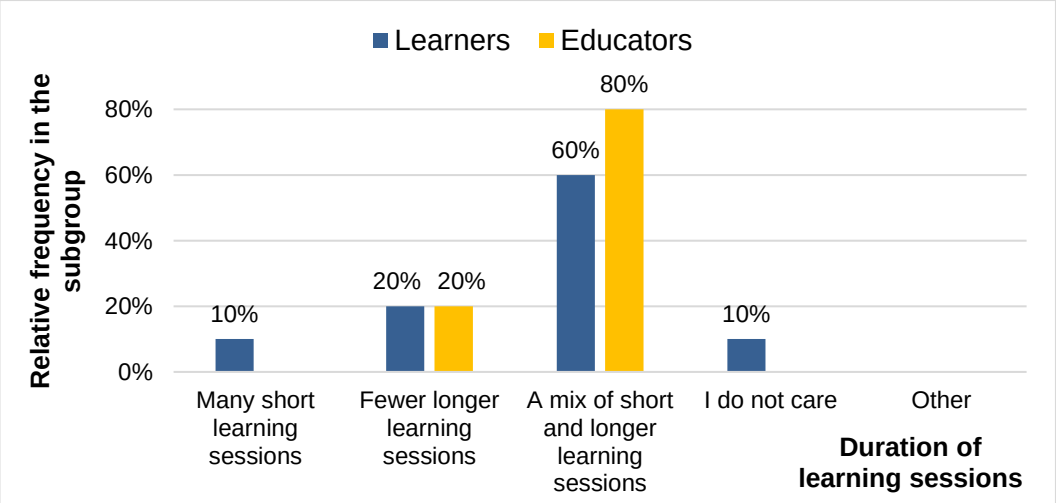
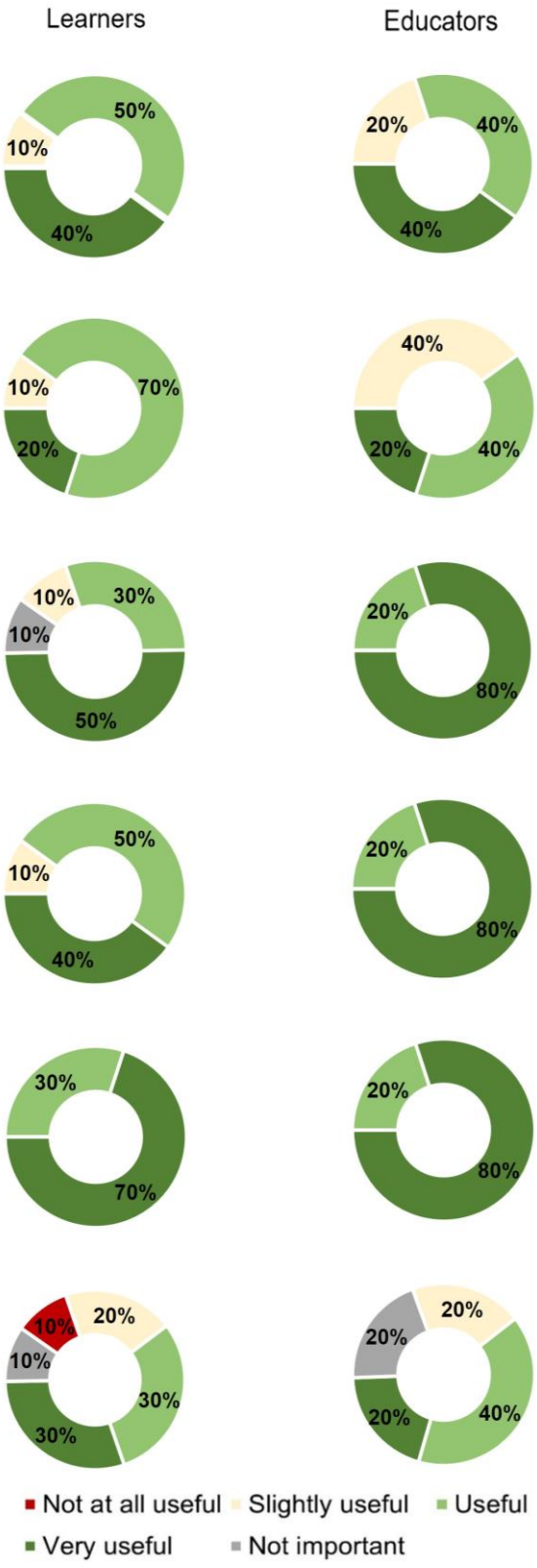


Figure 22: Comparison of the relative frequencies of the expectations for the length of the learning sessions of a mobile learning course on digital rehabilitation between the learner and educator subgroups. Own illustration.

As with the sub-questions on barriers and facilitators, all of the proposed features in the sub-questions on expectations of question Q16 were rated as useful or very useful by at least 50% of participants in both subgroups (see Figure 23). However, there are minor differences between subgroups on some features. The ten sub-questions show that the support of an educator is generally considered useful by both subgroups. However, the support of an educator before the course was rated least useful by educators and learners. Support during and after the mobile course was considered equally useful by learners (10% = slightly useful, 50% = useful, 40% = very useful). In comparison, educators perceived educational support to be less useful during a course (20% = not very useful, 40% = useful, 40% = very useful) than after a mobile course (20% = useful, 80% = very useful). Contact with other participants of the same or a previous course was not rated as particularly very useful. Hereby, mandatory contact was rated as less useful than optional contact, and learners rated the optional contact as more useful than the educators. Video content was the only one of the proposed features rated as useful or very useful by all participants in both subgroups. Video content in English was rated as useful as video content in general by educators, while learners rated video content in English as slightly less useful than video content in general. 80% of the educators and learners perceived interactive video content as useful or very useful. Only 60% of learners stated that using pictures instead of text is useful or very useful, while 20% stated that it is not useful at all. For educators, 80% considered pictures instead of text to be useful, while 20% did not consider it important. Quizzes to consolidate course content were rated as very useful or useful by 60% of educators and 90% of learners.


Learners
Educators
50%
10%
40%
20%
40%
40%
Support of an educator during the mobile course
10%
70%
20%
40%
20%
40%
Quizzes to consolidate the course content
10%
30%
10%
50%
20%
80%
Optional online contact to other participants of the same or a previous course
50%
10%
40%
20%
80%
Support of an educator after the mobile course
30%
70%
20%
80%
Video content
10%
20%
10%
30%
30%
20%
20%
20%
40%
Mandatory online contact to other participants of the same or a previous course
Not at all useful
Slightly useful
Useful
Very useful
Not important

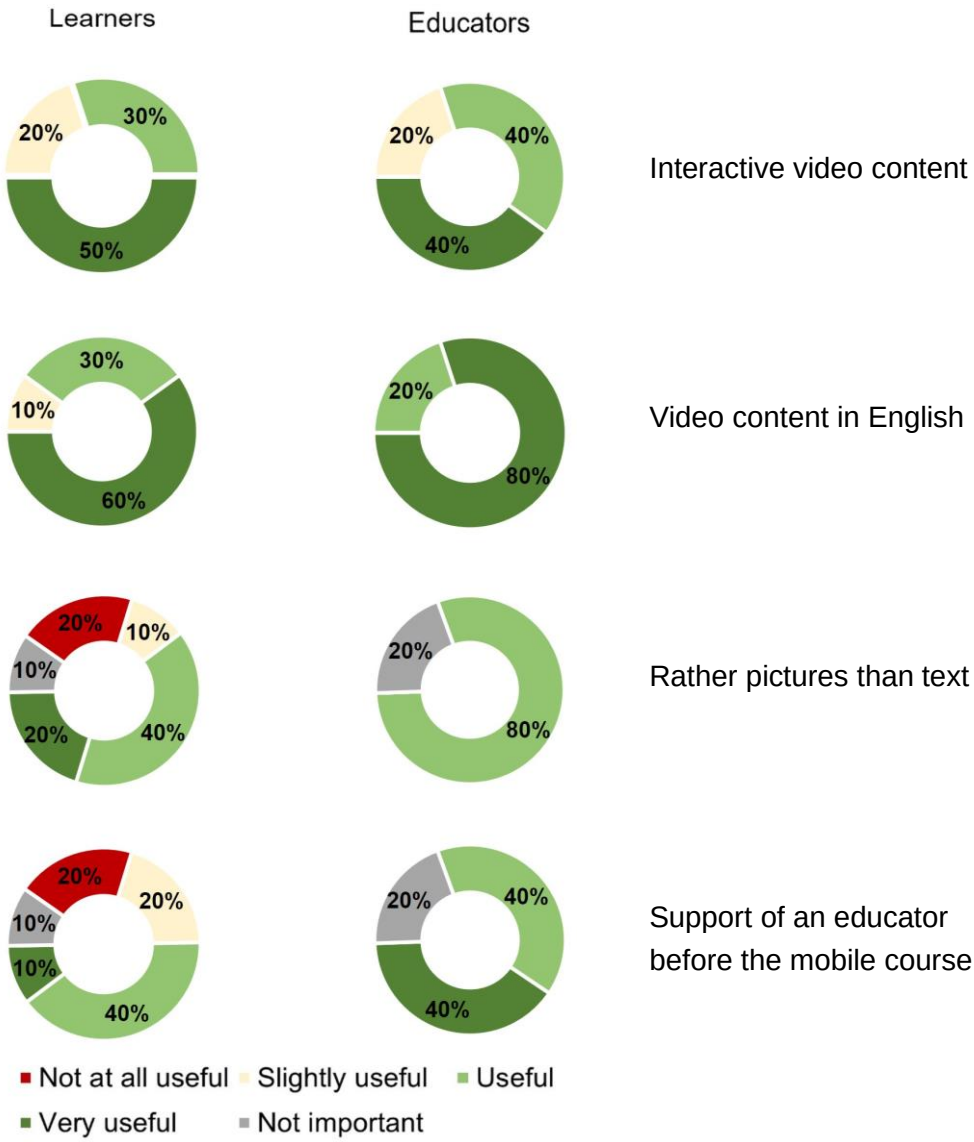


Figure 23: Comparison of the relative frequencies of perceived usefulness of features regarding the expectations for mobile learning on digital rehabilitation between the subgroup's learners and educators. Own illustration.

The open-ended question about why the participant would or would not be interested in a mobile learning unit for digital rehabilitation was a mandatory question. The answers to this question were evaluated in two upper categories with subcategories (see Table 13 and Table 14).

Overall, seven out of ten learners (70%) and four out of five educators (80%) indicated that they would be interested in a mobile learning unit on digital rehabilitation.

The question about the reasons for their interest resulted in 13 mentions, related to their own benefit and two to the benefit of patients. The two most frequently named benefits of their own were time savings and the fact that it is possible to do the course from anywhere. One learner explained that the possibility of learning anywhere *"… helps to deal with distractions in live classes…"* (ID 13, L, Q20). Cost savings were cited second most often. Five other benefits were mentioned once each (see Table 13). Improving the quality of healthcare services and reducing the shortage of rehabilitation professionals are cited as benefits to patients. Three mentions were not assignable to any category and did not form a separate category. One was that it is *"… easily accessible to all…*" (ID 9, E, Q20), and the other was that "… *in the wake of Covid - 19, it will help control the risk of exposure to the virus…"* (ID 9, E, Q20). The third mention related to patient empowerment, that "… *We need to start learning how to teach our patients on how to get information that may prevent the increase of the condition and rather empower them to do more for their social participation.*" (ID 18, L&E, Q20). Overall, more learners than educators indicated time saving as a personal benefit. As for cost savings, only educators indicated that this is a personal benefit. No other similarities or differences were found between these two subgroups.

20% of learners and 20% of educators indicated they were not interested in a mobile learning unit on digital rehabilitation. Most mentions were made in the subcategory Not relevant (see Table 14). One person reported that it would not be "… *very useful in my particular profession or setting*" (ID 28, L, Q20). Another person indicated that there is little learning matter available in the professional field. Lack of time was mentioned once with the argument that "*some of us are studying part-time*" (ID 19, L, Q20). One mention within the subgroup learners was "*No idea*" (ID 15, L, Q20), which was not assignable to any of the two upper categories. No other subcategory was formed for this category either, and no other similarities or differences were found between the two subgroups of educators and learners.

Table 13: Results of the upper category *Interest in mobile learning on digital rehabilitation* and its subcategories from the qualitative evaluation. | UC = Upper Category, SC = Subcategory. Own illustration.

Category	Definition	Number of mentions	Codes & Content
UC 6: Interest in mobile learning on digital rehabilitation	Reasons for the interest of working and aspiring health professionals in mobile learning offers on digital rehabilitation	15	-
SC 6.1: Own Benefits	Own benefits that mobile learning on digital rehabilitation offers to health professionals	13	ID 11, L, Q20 ID 13, L, Q20 ID 22, L, Q20 ID 26, L, Q20 ID 20, L&E, Q20 ID 9, E, Q20 ID 21, E, Q20 Saves time 3x Can be done from anywhere 3x Less costly 2x Whatever content is interesting 1x Improve knowledge and skills 1x Links to more information 1x Content is mostly simple and self-explanatory 1x Interactive sessions with other learners 1x
SC 6.2: Benefits for the patients	Benefits that mobile learning on digital rehabilitation offers to the patients of health professionals	2	ID 24, L, Q20 ID 18, L&E, Q20 Improves quality of health services 1x Reducing the shortage of rehabilitation professionals 1x

Table 14: Results of the upper category *No interest in mobile learning* on digital rehabilitation and its subcategories from the qualitative evaluation. | UC = Upper Category, SC = Subcategory. Own illustration.

Category	Definition	Number of mentions	Codes & Content
UC 7: No interest in mobile learning on digital rehabilitation	Reasons why health professionals are not interested in mobile learning offers on digital rehabilitation	3	-
SC 7.1: Lack of time	Reasons why health professionals do not have enough time for mobile learning on digital rehabilitation	1	ID 19, L, Q20 Part-time studies 1x
SC 7.2: Doubts about the quality	Reasons why health professionals have doubts about the quality for mobile learning on digital rehabilitation	0	-
SC 7.3: Not relevant	Reasons, why mobile learning on digital rehabilitation is not relevant to health professionals	2	ID 28, L, Q20 ID 27, E, Q20 Not useful for the profession and setting 1x Little learning matter 1x

4.2.3 Summarized results of the online survey

Table 15 in this chapter summarizes the key findings of the online survey for each evaluation category. It illustrates where there are similarities and differences in the responses of learners and educators.

Table 15: Summary of the results of the online survey, categorized into the evaluation categories. Own illustration.

Differences	Similarities
(1) Personal and (2) Professional Background	
• Learners: - work mainly in the urban area (70%) and only 30% in the rural area • Educators: - 70% with an educational level of at least a master's degree - almost 10 years more work experience - are on average about 10 years older - work mainly in both urban and rural area (60%) - no nurse	• Broad age distribution • Almost equal number of men and women • Participants from East Africa, West Africa, and South Africa • All professions except nurses
(3.1) Own experiences with mobile learning for basic and further education for health professionals in sub-Saharan Africa	
• Learners: - most technology used to expand knowledge was app on a smartphone or mobile device. Second most was social media. - used more video conferencing • Educators: - more have already heard about mobile learning - more have already used mobile learning themselves - most technology used to expand knowledge was video conference, second most used apps, and emails. - used more learning platforms	• 60% in each subgroup used apps on a smartphone or mobile device. • WhatsApp and Zoom were mentioned most often

Differences	Similarities
(3.2) Barriers and facilitators to mobile learning for basic and further education for health professionals in sub-Saharan Africa	
• Learners: - for 30%, data privacy is an important issue - tend to be more concerned that the course might be too expensive. However, 60% disagree or strongly disagree - 80% have no problems with using a digital device - but 20% have - Barriers: explanation of device use is less important, but lack of technical skills are more important / technical support less important / language barrier more important / electricity more important Lack and costs of a laptop - Facilitators: offline content most important • Educators: - no one concerned about data security - no one concerned that the course might be too expensive - no one concerned about not being able to use a mobile device - Barriers: technical support more important / language barrier less important / electricity less important - Facilitators: 3x60% = offline content, personal visits by a trained person to health professionals in their own setting and the explanations of device use	• Majority of learners and educators are not concerned about data privacy. • In both subgroups 20-30% are concerned that the content might not be of good quality. • Educators and Learners see Internet connection as the biggest barrier and Internet quality and Internet cost in second place. • In both subgroups, only 20% see access to a mobile device as a barrier.

Differences	Similarities
(4.1) Barriers and facilitators to mobile learning to educate working and aspiring health professionals in sub-Saharan Africa on digital rehabilitation	
• Learners: - find it even more important than educators to be able to save their progress at any time - rated playable text less useful • Educators: - 20% stated that subtitles in the native language were not useful at all - Recreational places for access to educational materials	• All educators and almost all learners indicated to access educational material retrieve from home. From the educational institution second most often. In addition, in both subgroups more participants indicated to use it more indoors than outdoors. Response option other was used in both subgroups and at work was added in both subgroups. • More useful to save progress at any time rather than after a submodule. • More useful to have subtitles in the language of the video, in this case English, than subtitles in their native language. - However, both options were found to be generally useful. • Of all the features, downloadable content was rated most often as very useful by both subgroups. • Playable text was rated less useful than the other features by both subgroups.
(4.2) Expectations for mobile learning to educate working and aspiring health professionals in sub-Saharan Africa on digital rehabilitation	
• Learners: - 30% do not want live classroom lessons - found support of an educator during and after the course equally useful - considered optional contact to other participants more useful than the educators - found English language video content slightly less useful than video content in general - pictures instead of text was perceived less useful • Educators: - all would like live classes - perceive support of an educator after the course even more useful than during the course - all found optional contact to other participants useful or very useful - all found quizzes useful or very useful	• Majority of educators and learners want optional live classroom lessons. • A mixture of short and long sessions was rated best. • The support of an educator before the course was rated least useful. • Contact to other participants was rated to be not very useful. Optional contact was rated better than mandatory contact. • Video content is the only feature in both subgroups that was rated useful or very useful by all participants. • Interactive video content was perceived positively by all participants (80% per subgroup) but rated as slightly less useful than video content in general.

4.3 The digital guidebook

The online survey and the literature research identified the needs of working health professionals in sub-Saharan Africa for mobile learning, with a specific focus on digital rehabilitation. No differences were found in terms of needs for mobile learning for basic and further education and digital rehabilitation, and in addition, no major differences were found between the needs of learners and educators. Therefore, all survey results were considered in the creation of the digital guidebook.

Based on the literature research and the survey results, an interactive learning video was created to serve as a digital guidebook for educators. It highlights the needs and explains how to meet them. Since no aspiring health professionals participated in the survey, only a conclusion about mobile courses for working health professionals is possible.

The title of the digital guidebook is: *What to consider when developing a mobile learning course on digital rehabilitation for health professionals in sub-Saharan Africa.*

This digital guidebook is part of a digital handbook created by the Erasmus+ project DIRENE and can be accessed on the website of the Jyväskylä University of Applied Sciences at https://www.jamk.fi/en/project/direne/handbook.

4.3.1 Persona representing the target group

A persona was created to get a better idea of the target audience (see Figure 24). Here, the demographic data of the educators from the survey were considered. The characteristics of this persona were used for the person in the interactive learning video. This was to help viewers better identify with the person in the video.

Personal characteristics

Name: Linda Opoku

Age: 43 years

Sex: Female

Nationality: Ghana

Civil status: Married, one child with her husband

Hobbies: Sometimes she works out at home using sports videos from YouTube. She likes to drive out of the city with her family on the weekends or meet up with friends.

Short biography:
She originally comes from a rural area close to the city. Her mother still lives there. Her father died a few years ago. She came to the city to study. Now she lives with her family in a flat in the center of the city. She continues to live here because she has better job opportunities and has come to value a city's infrastructure.

Profession and education

Profession: Physiotherapist

Education: After school, she studied physiotherapy for a bachelor's degree, and a few years later, she added a master's degree in physiotherapy.

Current work situation: She is a physiotherapist and teaches continuing education courses for physiotherapists. In addition, she works in a public hospital where she treats inpatients and outpatients from all medical fields.

Professional goals: Her goal is to treat not only the urban population, but also people in rural areas. She knows from her own experience that access to the healthcare system is much more difficult there. She also wants to ensure that her course attendees always receive up-to-date and evidence-based content.

Digital experience

Linda has some technical experience. She has both a smartphone and a Laptop and uses them regularly to prepare for classes at university or to exercise at home. She has also provided therapy via video call when patients could not make it to the hospital.

She is very interested in the use of digital technologies in therapy. A few months ago, she watched a video on YouTube on digital rehabilitation and now uses some of the tools she learned in treating her patients.

Goals and wishes

She recognizes the great benefit of digital rehabilitation for the rural populations and wants to share her knowledge of it with other therapists and students in health professions in her country. For this, she would like to create an online course where she can share what she has learned.

However, she has never done anything like this before and does not know what to consider when designing an online course. She wishes she could get some useful tips on how to create such a course.

Figure 24: Persona representing the target group of the digital guidebook. Own illustration.

4.3.2 Content

The interactive video presents the needs of working health professionals in sub-Saharan Africa for a learning unit on digital rehabilitation, which were identified through the literature research or the online survey and explains how to meet them.

It has been shown that videos and interactive elements such as quizzes or podcasts are useful for learning (Alam et al., 2016; Barteit et al., 2018; Hew & Lo, 2018) and are preferred by health professionals in sub-Saharan Africa in their roles as learners and educators. The survey found that subtitles should be available in English and possibly other native languages. In addition, the content should be presented in a mix of longer and shorter learning units, and the achieved progress should be savable at any time. The ability to save the achieved progress at any time allows the learner self-paced learning.

Pre-course mentoring by an educator was perceived as the least useful, but there were also participants, particularly in the learner group, who were concerned about not having sufficient technical skills to participate in mobile learning. For this reason, prior to the mobile course on digital rehabilitation, there could be an optional short video explaining how the course works and what technical skills are needed. However, the course should not require any special technical knowledge. Further, the support of an educator during and after the course was rated as very useful. Therefore, participants should have the opportunity to ask questions to an educator during the course and for several weeks after completion of the course. This would be possible, for example, via an instant messenger or text messages within the mobile learning unit.

Additional optional classroom lessons were also found to be useful, especially by educators, and by some learners. One way to meet this expectation is to provide classroom lessons to course participants on various topics covered in the mobile learning course on digital rehabilitation. However, completing the course should always be possible without attending these live classes. In addition to the contact with the educators, the contact with other or former participants was found to be useful. A forum with unlimited access so that former participants can also benefit from the knowledge in the community is a possible solution for this. However, the time for the participants to complete the course needs to be regulated, for example, to a maximum of two months. Otherwise, there might be too many requests to the course educators or too many participants in the additional classroom lessons.

Some educators and learners were concerned about the quality of the content of the mobile courses. To address this, it may be beneficial to work with a university that offers the course and thus provides proof of quality. Upon successful completion of the course, the participant should have the option to download a certificate confirming the successful completion.

Learners also indicated that the course might be too expensive. Ideally, the course is offered once free of charge for students in a health profession and working health professionals. This could be achieved through funding, but this is often difficult.

Since more people own a smartphone than a computer (International Telecommunication Union, 2020), the course should be easy to complete, especially with smartphones. Further, web browsers and apps were cited in the literature as the most common forms of mobile learning for health professionals in sub-Saharan Africa (Kynge, 2020; Masika et al., 2015). Learners also reported that the lack of laptops and their cost are barriers to mobile learning. Therefore, it should be possible to participate in a mobile learning unit on digital rehabilitation via an app or web browser on a smartphone. However, since long sessions with the smartphone were perceived as exhausting, the longer learning sessions should not last too long.

It has to be noted that both the literature and the online survey found that Internet connectivity and poor network coverage are one of the biggest barriers to mobile learning (World Health Organization, 2019). In addition, mobile data is still very expensive for the population in sub-Saharan Africa (World Health Organization, 2019). Accordingly, the survey participants rated offline content as very useful. Thus, the app or the content in the web browser should be usable offline after the download. This also fulfills the expectation of being able to access content anywhere. By keeping the course offline as much as possible, persons who have concerns about data privacy might participate in the course as well.

To reach potential participants, it is advisable to disseminate the course via social media or text messages (SMS or instant messenger) with a corresponding link to the course.

Because lack of knowledge about digital device use is a barrier cited in the literature (World Health Organization, 2019) and was confirmed by the survey, in-person visits by a trained person to health professionals in their own settings with explanations of device usage are advisable to engage more health professionals. During such a visit, it is possible to clarify questions and highlight the benefits and ease of use of the technology to improve adoption (Hicks et al., 2021). In addition, this will help raise awareness of the course.

4.3.3 Story and design

The interactive learning video was divided into four shorter video clips, with the shortest being 4 minutes long and the longest being 5 minutes and 31 seconds long. After a title screen (see Figure 25), at the beginning of each video clip is a recap of what happened in the previous video and/or what the viewer awaits in this video clip. This part varies in length. However, it does not exceed one minute. At the end of each clip, there is a short closing credit of 30 seconds that refers to the master thesis, the author, the master's degree program, the University, the DIRENE project, and the Erasmus+ program. A copyright notice is also displayed stating that the work is licensed under the Creative Commons license CC BY-NC-ND 4.0[9] (Attribution-NonCommercial-NoDerivatives 4.0 International).

In total, all video clips contain eleven interactive elements. Five of these are single-choice questions, two are multiple-choice questions, and four are drag-and-drop tasks. Six interactive elements form a quiz at the end of the last video clip to consolidate the content. Each time an interactive element is displayed, the video pauses until the question is answered correctly. This gives the viewer enough time to answer the question. Only if the answer is correct the viewer can continue watching the video.

In the video, the aspects that should be considered when creating a mobile learning unit on digital rehabilitation for health professionals in sub-Saharan Africa are explained by a woman with characteristics of the created persona for the target group. A woman was taken for the video, but a man would have been just as possible. This woman lives in sub-Saharan Africa, is a physiotherapist and educator herself, and wants to share her knowledge of digital rehabilitation with colleagues and students in health professions. Viewers follow her on the journey to create a mobile learning unit on digital rehabilitation for health professionals in sub-Saharan Africa. Thus, the educator watches a person who is currently in the same situation as he or she is.

The videos are accessible online at https://sway.office.com/9koBpBtisZVpgphK. All videos are stored on the Microsoft SharePoint[10] of St. Pölten University of Applied Sciences (Austria), from where they are downloadable via separate links on the website. Since the video clips have been converted to HTML for offline viewing, the videos must be downloaded to watch them.

[9] https://creativecommons.org/licenses/by-nc-nd/4.0/

[10] https://www.microsoft.com/en-us/microsoft-365/sharepoint/collaboration

The first video clip, titled *Introduction,* is 5 minutes and 31 seconds long and first introduces the viewer to the character Linda. It then gives an overview of the healthcare situation in sub-Saharan Africa and tells Linda's first experience with digital rehabilitation. The first video clip contains one single-choice question. The second video clip shows Linda thinking about how to develop a mobile learning course for health professionals in sub-Saharan Africa on digital rehabilitation and presents the initial results. It contains one single-choice question as well (see Figure 26), is 4 minutes long, and is titled *Linda's first ideas for designing the course*. In the third video clip, viewers join Linda at her lunch at work (see Figure 27), where she gets tips from her colleagues on how best to create the course. During this video clip, which is 5 minutes and 17 seconds long and titled *Helpful tips from Linda's work colleagues*, the viewer is asked two single-choice questions. In the fourth and thus last video clip, Linda gets more tips from her husband Tim and summarizes all her findings with the support of the viewer (see Figure 28). This video clip is 4 minutes and 37 seconds long and contains a multiple-choice question and the final quiz, which consists of a single-choice question, a multiple-choice question, and four drag-and-drop tasks. The last video is titled *More tips and a summary of the results*.

Link to the first video clip:

https://fhstp-my.sharepoint.com/:u:/g/personal/akidritsch_fhstp_ac_at/EcIcS0dsv_tBm0-opbv2XRwBRmmMbYK8fa8WjZg4h53pyQ?e=AzAHul

Link to the second video clip:

https://fhstp-my.sharepoint.com/:u:/g/personal/akidritsch_fhstp_ac_at/EZdjlV9T1c1Ks4VhUuO7af8BDJdbGShi-HP22qEsszaXZw?e=DlnUnE

Link to the third video clip:

https://fhstp-my.sharepoint.com/:u:/g/personal/akidritsch_fhstp_ac_at/EV9ZYyBUD8tHgpRcKzgZbtgBLflbf6a6P99tDWvkoht-7Q?e=CeFBeE

Link to the fourth video clip:

https://fhstp-my.sharepoint.com/:u:/g/personal/akidritsch_fhstp_ac_at/ERFq6u2YdVZJm5ZbLwDdfWYBJQ2a7Daj2ZmublrnCYuO5Q?e=Fshc7j

Figure 25: Video still of the title screen displayed before each video clip. Own illustration.

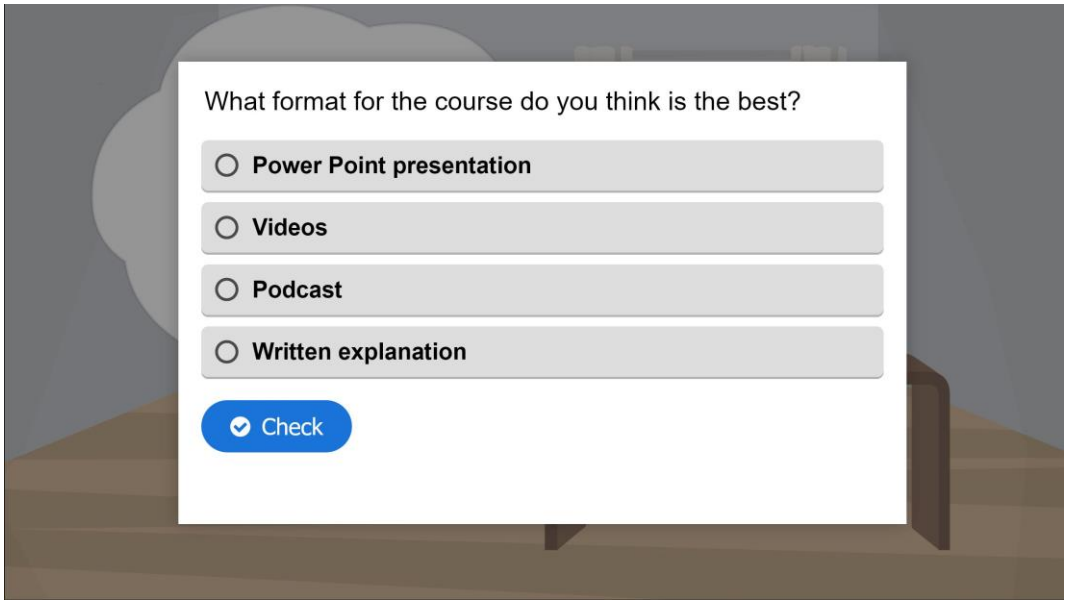


Figure 26: Video still of the single-choice question in the second video clip. Own illustration.

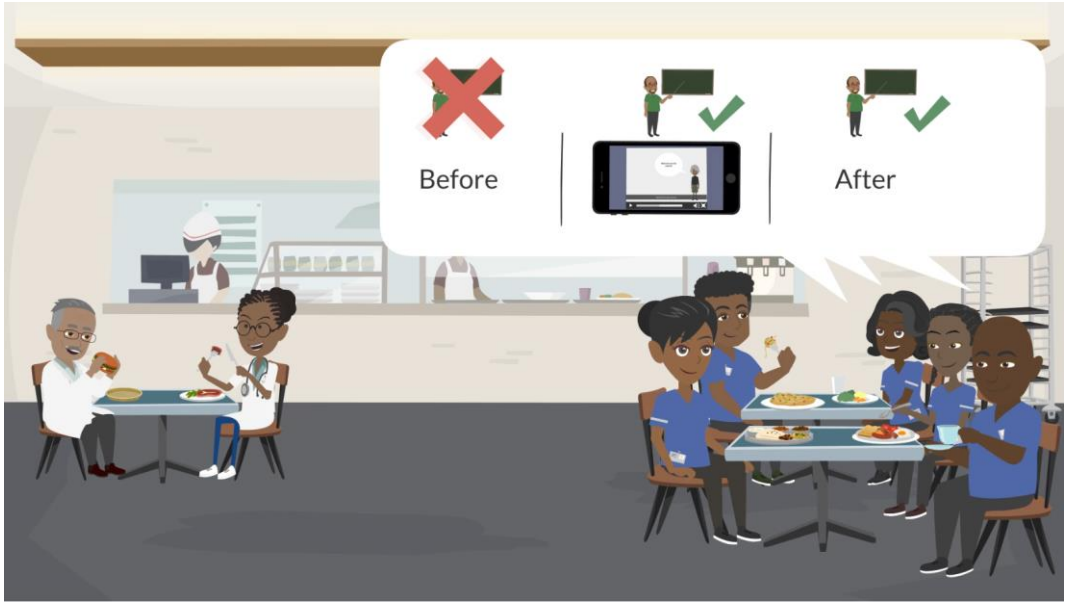


Figure 27: Video still of a scene from the third video clip where Linda gets tips from her work colleagues. Own illustration.

Figure 28: Video still of the summary in the fourth video clip on all the aspects mentioned in the four videos. Own illustration.

5 Discussion

This work aimed to develop a digital guidebook as a resource for educators to create mobile learning units for health professionals on digital rehabilitation in sub-Saharan Africa. For this purpose, literature research, as well as empirical research in the form of an exploratory cross-sectional study, were conducted to answer the research question *What are the needs of working and aspiring health professionals in sub-Saharan Africa in their roles as educators and as learners concerning mobile learning on digital rehabilitation?* A mixed methods questionnaire was created based on literature research and a group discussion with the African partners of the ERASMUS+ project DIRENE. This questionnaire was then used in an online survey.

In general, no differences were found in terms of needs for mobile learning for basic and further education compared to mobile learning for digital rehabilitation. Furthermore, no major differences were found between the needs of learners and educators concerning mobile learning on digital rehabilitation. In some cases, the learners agreed or disagreed more with a statement than the educators, but there was no case where the discrepancy was large. Thus, it can be concluded that the needs for educators and learners are the same, but in some cases with different intensities. No aspiring health professionals participated in the survey. Therefore, the findings can only be used to draw a conclusion about mobile courses for working health professionals. The following needs were identified:

(1) Needs regarding the design of the content

- Videos
- Interactive elements
- English
- Optional English subtitles
- Subtitles in other native languages
- Achieved progress can be saved at any time
- A mix of longer and shorter learning units
- Longer learning sessions should not last too long

(2) Technical needs

- Easy to complete with smartphone
- Participation via an app or web browser
- Doable without special technical knowledge
- Offline content
- Ensuring data security

(3) Needs for educational support

- Support of an educator during and after the course
- Additional optional classroom lessons
- Contact with other or former participants
- Explanations on the use of digital devices

(4) Needs for infrastructure

- Stable electricity supply
- Access to a digital device

(5) Further needs

- Financial support for course fees
- Downloadable certificate
- Confirmation of the quality of the course
- Dissemination via social media, instant messenger, and though private visits to health facilities

Through the open-ended questions and the possibility to choose other in the closed questions, the participants were always given the opportunity to contribute their own ideas. However, selecting others in the closed questions was rarely used, and most of the answers in the open-ended questions were assignable to one of the deductively created categories. This shows that the questionnaire was able to address the central topics. Nevertheless, a few answers to the open-ended questions were not assignable to any subcategory. This demonstrates that not all relevant aspects are described in the literature or were not found through the literature research. Some of the deductively created subcategories were not mentioned by the participants. Since some of these topics were already covered by the closed questions, this could be the reason why no further mentions have occurred.

The empirical results of this study confirmed some facilitators identified by the comprehensive systematized literature review. These are offline content (Barteit et al., 2018; Olum et al., 2020), videos (Holst et al., 2021), multimedia content as well as interactive exercises (Barteit et al., 2018), a blended learning environment (Olum et al., 2020), the support of an educator after a course (Asgary et al., 2019) and the use of social media for medical education (Rusatira et al., 2016). The facilitator continuous on-the-job training (Ayanore et al., 2019) was not mentioned by any of the participants of this study. However, participants in this study mentioned other facilitators such as explanations of how to use devices, chatbots to train people on digital rehabilitation services, senior workmates, and downloadable certificates that were not found in the literature.

Further, most of the barriers identified in the comprehensive systematic literature review are consistent with the findings of this study. These are poor Internet connectivity (Hicks et al., 2021; Kynge, 2020; Masika et al., 2015; Olum et al., 2020), lack of technical skills (Barteit, Jahn, et al., 2019; Masika et al., 2015; Olum et al., 2020), limited access to digital devices (Kynge, 2020; Masika et al., 2015; Olum et al., 2020), lack of time due to a high workload (Hicks et al., 2021; Kynge, 2020), costs (Masika et al., 2015; Olum et al., 2020) and poor power supply (Hicks et al., 2021; Olum et al., 2020). Not mentioned in this study was the lack of relevant and up-to-date material (Barteit, Jahn, et al., 2019; Kynge, 2020) and that the need to own an email address for registration is perceived as a barrier, as noted by Kynge (2020). Barriers identified in this study but not found in the literature include access to programs, lack of awareness of the amount of information health professionals can obtain using mobile devices, and language barriers.

When comparing barriers and facilitators identified from the literature research and from the survey, it should be considered that the literature research also included barriers and facilitators regarding eLearning. The study, in contrast, only asked the participants about barriers and facilitators for mobile learning.

A comparison with two studies that also created a mobile learning course for people in sub-Saharan Africa shows some differences, but also similarities in the results. Holst et al. (2021), who created a health education platform for rural populations in sub-Saharan Africa, used the Human Centered Design process to explore the needs of the target group. This study discovered that the mobile phone is used more by the population than other digital devices. In addition, the target group preferred content to be presented in animated videos along with graphics and quizzes as well, and the application should be usable even with only limited digital skills. For the target group of Holst et al. (2021), another important aspect was that videos were also available in the local language, Swahili. The participants do not share this need in this study. Most likely, this difference is caused by the fact that the target group of this study has a higher level of education than the average population in the rural area and thus had much exposure to the English language already. Dione et al. (2021) developed an interactive voice response to educate farmers on biosecurity through mobile phones. In this process, they discovered that the combination of face-to-face training and voice calls further improved farmers' knowledge. In addition, as in this study, the information was presented in a story to make it easier to remember and increase the chance of completing the course.

Limitations

In contrast to Holst et al. (2021) and Dione et al. (2021), for this study, it was not feasible to recruit and interview people from the target group on-site. Therefore, the first limitation of this study concerns the recruitment of the subjects and, thus, at the same time, the study population. In the first step of the recruitment, the questionnaire was sent to the African partners of the DIRENE project who have already been involved in digital rehabilitation and mobile learning and therefore already have more knowledge on this topic. In the second step, individual medical science colleges and universities, as well as therapy facilities, were specifically contacted. However, these could only be contacted if they were listed on Google Maps, had a website and an email address. These requirements imply that facilities are most likely to be located in an urban area, have good network coverage and that healthcare staff already have a good digital literacy. In general, only health professionals who had access to the Internet and a digital device were able to participate. Since the study was only available in English, participants also had to be proficient in reading and writing English. It can be assumed that health professionals do not have difficulties with English because of their higher level of education, but not all sub-Saharan countries speak English. This might explain why only health professionals from countries with English as an official language participated. These limitations, as well as other factors like the distance to the participants, could be the reason why the original target of 20 study participants was not reached. The small number of participants is also a limitation of the study population.

A second limitation lies in the creation of the questionnaire for the online survey. The questionnaire was based only on literature research in English-language literature, which means that studies in other languages were not considered in the literature research and thus in the construction of the questionnaire. In addition, the questionnaire was quite extensive, with 32 questions, which may have been the reason why six people did not complete the questionnaire in full.

A critical view of the evaluation of the results shows further limitations. Contrary to the recommendation of Betjeman et al. (2013), the results of this study, which reflect the opinions of people from five countries in sub-Saharan Africa, were generalized to the entire region. At least these five countries were distributed among East, West, and South Africa, but no person from a country in Central Africa participated. Another point to discuss is the assignment of participants to their roles as educators, learners, or both. Here, working health professionals were assigned to learners because they have no experience as educators. However, none of them had attended a course at the time of the survey.

Working health professionals with teaching experience who had attended a course at the time of the survey were assigned to both subgroups. Thus, the responses of these persons were counted twice. However, it was not reasonable to expect them to respond from the perspective of one role, since they combined both. This assignment resulted in 10 responses being evaluated in the learner subgroup and only 5 in the educator subgroup. Despite the small number of participants, the evaluation was primarily performed by calculating and comparing the relative frequency because of the unequal distribution in the two subgroups. A larger and more equal number in the subgroups, as well as a better sense of participants' belonging to a role, either learner or educators, could provide clearer results as well as clearer differences between learners and educators. To improve the sense of participants' belonging to a role, the learner subgroup could include only health professionals who attend a course, and the educator subgroup could include only health professionals who primarily teach.

Since no differences were found between the needs for mobile learning in basic and further education in general and digital rehabilitation, nor between the needs of learners and educators, almost all identified needs were included in the digital guidebook. However, some aspects were not considered for various reasons. This applies, for example, to the barriers electricity and access to a digital device, which clearly hinder participation in mobile learning. Nevertheless, they are not included in the video clips because they cannot be influenced by the design of the mobile course. One option to meet these barriers is to provide power banks for students at a university, as well as on-demand computers in the university building. For working health professionals, employers are in a position to provide computers or smartphones at the workplace. In addition, some mentions of the participants from the open-ended questions as well as differences in the answers of learners and educators could not be considered. First, this is because individual mentions such as the integration of a chatbot that teaches digital rehabilitation content to participants already require higher technical skills and is not a must for a mobile learning unit on digital rehabilitation. Furthermore, integrating every single mention from the study participants would have expanded the content and, therefore, length of the video clips, though it is not clear how important each mention is. Second, integrating all the differences in the learners' responses and the educators would have compromised the comprehensibility of the video clips.

In designing the digital guidebook, the intention was to include as many as possible of the study's findings regarding the content design and technical needs. However, with the software used, it was not possible to include optional subtitles, progress cannot be saved during a video clip, and no special precautions were taken for data security.

In summary, the study design using a mixed methods questionnaire was well suited to answer the research question. However, the informative value of the results is limited because of the limitations mentioned above. Thus, the needs identified in this study can be related primarily to working health professionals in English-speaking countries in sub-Saharan Africa who have at least reasonably stable access to the Internet and have already been exposed to digital services. Consequently, the digital guidebook is also more suitable for this target group.

6 Conclusion

Considering the shortage of health workers, which is especially high in sub-Saharan Africa, mobile learning offers a huge opportunity to improve health care and train more health professionals. Through empirical research and literature research, it was possible to show that there is an interest in mobile learning on digital rehabilitation among health professionals in sub-Saharan Africa.

Moreover, the special needs of the target group were identified. With this, it could be shown that interactive, English-language videos with optional subtitles in English and native languages are requested by health professionals in sub-Saharan Africa when designing a mobile learning course on digital rehabilitation. Further, participants should be able to save their progress at any time. The course itself should consist of shorter and longer learning units, whereby the longer units should not be too long, as long units are exhausting to follow on a mobile device. In terms of technical requirements, it was discovered that the course should be easy to complete via an app or the web browser on a smartphone and that no special technical knowledge is required. In addition, it is essential to offer offline content as much as possible and to ensure data security The study participants requested educational support during and after the course from an educator, as were additional optional classroom lessons and the opportunity to connect with other or former course participants. The need for explanations on the use of digital devices was also expressed. Further needs include financial support for course fees, a downloadable certificate, confirmation of course quality, and dissemination of the course via social media, instant messenger, and private visits to healthcare facilities. Needs regarding infrastructure were also mentioned. These are stable electricity supply and access to a digital device. However, these factors are not influenceable by the design of the mobile course and were therefore not included in the digital guidebook.

The needs of educators and learners identified in this work were used to create a digital guidebook consisting of four video clips that can now be used to train educators. However, further studies should be conducted to examine the usefulness and acceptance of the videos among the target audience. In addition, a larger study with participants who feel they belong better to one role, either learner or teacher, might provide clearer results regarding the differences between learner and educator needs.

Building on the results of this work, conducting further surveys in other sub-Saharan African countries on the same topic would help to determine whether the results are transferable to other countries in the region. Further, the results were collected in the context of mobile learning and digital rehabilitation. However, whether they also apply to mobile learning in other medical areas such as neurological patient care has not been proven.

As identified by Opoku et al. (2017), contextual factors also contribute to the success of mHealth initiatives in sub-Saharan Africa. The conducted literature research did not clearly reveal information on contextual factors that influence the success of mobile learning in healthcare. Further studies in this area might identify possible contextual factors that contribute to the success of mobile learning in healthcare, allowing more health professionals to be educated.

Digital rehabilitation provides an opportunity to address the emerging shortage of health professionals, especially in sub-Saharan Africa. However, as identified in this work, even graduate health professionals are concerned about not having adequate technical skills when using digital devices. The literature research revealed that there had been an increase in the number of CHWs performing simple medical tasks in sub-Saharan Africa. The tasks include providing health information to individuals and the community, collecting data to monitor a person's health status, distributing medical supplies, helping people access health services, and acting as a link between healthcare providers and communities (International Labour Organization, 2012). With technical training, CHWs could help the population use digital devices and help them to access digital health services such as digital rehabilitation. Further research should include this new professional group, as they could play an increasingly important role in the implementation of digital healthcare.

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Appendix

A. Synonym tables used in PubMed

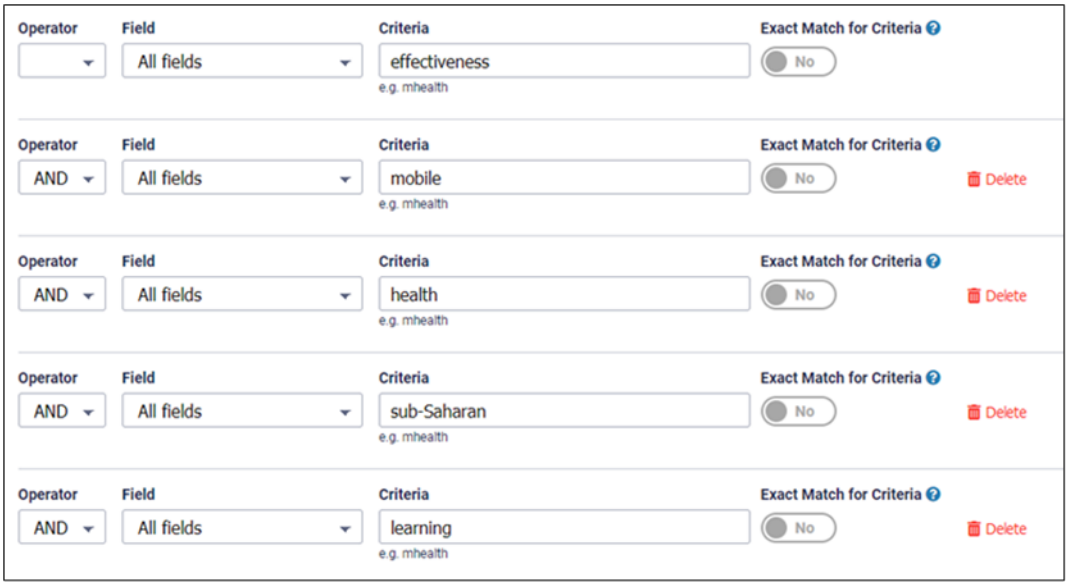
Synonym table used for the literature research on effectiveness of mobile learning to improve the knowledge and skills of working and aspiring health professionals in sub-Saharan Africa. Own illustration.

effectiveness	knowledge and skills	mobile learning	health professionals	sub-Saharan countries
power	ability	mLearning	health student*	sub-Saharan Africa
effect	understanding	mEducation	healthcare student*	low-income countries
success		mobile education	health care student*	low-income
usefulness		learning application	healthcare worker*	
value		online learning	health care worker*	
potency		mobile teaching	physio*	
efficiency		online teaching	occupational therap*	
efficacy		teaching application	therapist*	
		mTeaching	speech therap*	
			nurs*	
			midwife*	
			psycholog*	
			doctor*	
			medical staff	

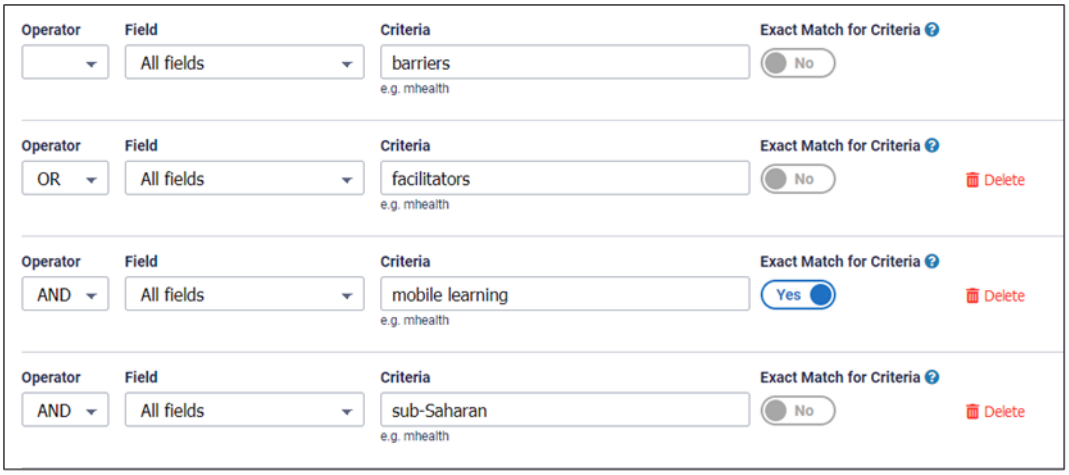
Synonym table for the literature search on barriers and facilitators of mobile learning in sub-Saharan countries. Own illustration.

barriers and facilitators	mobile learning	health professionals	sub-Saharan countries
obstacle	mLearning	health student*	sub-Saharan Africa
hurdle	mEducation	healthcare student*	low-income countries
limitation	mobile education	health care student*	low-income
drawback	learning application	healthcare worker*	
hindrance	online learning	health care worker*	
restriction	mobile teaching	physio*	
difficulty	online teaching	occupational therap*	
impediment	teaching application	therapist*	
promot*	mTeaching	speech therap*	
speed up		nurs*	
eas*		midwife*	
restrain		psycholog*	
support		doctor*	
foster		medical staff	
hinder			
delay			

B. Input masks used in JMIR



Input into the search mask for the literature search in JMIR on effectiveness of mobile learning to improve the knowledge and skills of health workers and aspiring health workers in sub-Saharan Africa (JMIR Publications, n.d.)



Input into the search mask for the literature search in JMIR on barriers and facilitators of mobile learning in sub-Saharan countries (JMIR Publications, n.d.)

C. Coding of the Questions

Coding of the questions of the questionnaire used in the online survey. Own illustration.

Code	Question
Q0	Declaration of consent I have read and fully understood the information about the study. I had enough time to decide if I wanted to participate in the study. All additional questions have been answered to my satisfaction by the study lead. My participation is voluntary and I am aware that I can withdraw from the study at any time, even without giving reasons, without incurring any disadvantages of any kind. I agree to the processing of the data collected for this study and I am willing to participate in the study. Hereby I confirm, that I meet all inclusion criteria. Please note that your informed consent is required to participate in the study. If you refuse consent, the survey will automatically end
Q1	How old are you?
Q2	What is your gender?
Q3	What is your highest educational qualification?
Q4	Do you have the citizenship or the center of life in a sub-Saharan country?
Q5	From which country in sub-Saharan Africa do you have the citizenship or have your center of life?
Q6	Are you a working professional?
Q6a	What is your occupation / profession?
Q6b	How many years of working experience do you have in this profession?
Q6c	Do you hold a leading position?
Q6d	Do you work in a rural or urban area?
Q7	Are you enrolled in a course or program of study for a health profession?
Q7a	What degree is expected after graduation?
Q7b	In which medical field is your training located?
Q8	Are you working as an educator to train health professionals?
Q8a	Which professions do you teach?
Q8b	Which educational level do you teach?
Q8c	How many years of experience do you have as an educator?
Q9	Have you used, heard about, or read about mobile learning for further or basic education for health professionals in sub-Saharan Africa?
Q9a	Which mobile learning program(s) have you used, heard about, or read about?

Q10	In the past 12 months, have you used any of the following to expand your knowledge about a topic from your profession?
Q11	Here are some thoughts about mobile learning for basic and further education of health professionals in sub-Saharan Africa. How strongly do you agree or disagree?
Q12	What barriers to mobile learning for basic and further education of health professionals in sub-Saharan Africa have you experienced, heard / read about, or could you imagine being clearly relevant?
Q12a	What other barriers than those listed before could you think of?
Q13	What facilitators with mobile learning for basic and further education of health professionals in sub-Saharan Africa have you experienced, heard / read about, or could you imagine being clearly relevant?
Q13a	What other facilitators than those listed before could you think of?
Q14	If you use a mobile device at least sometimes to access informational materials for your studies or further education, where do you normally use it?
Q15	If you had a choice between many short learning sessions (e.g., 10-15 minutes) or fewer but longer ones (e.g., 20-40 minutes). Which option would you choose?
Q16	How useful would you rate the following features of a mobile learning unit on digital rehabilitation?
Q17	Can you think of other features that could be especially useful for a mobile learning unit on digital rehabilitation?
Q18	Can you think of barriers that might prevent someone from participating in a mobile learning unit on digital rehabilitation?
Q19	Imagine you are participating in a mobile learning unit on digital rehabilitation. Would you like additional classroom teaching with other participants?
Q20	Please explain why you would or would not be interested in a mobile learning unit on digital rehabilitation.

D. Questionnaire

Declaration of consent

I have read and fully understood the information about the study. I had enough time to decide if I wanted to participate in the study. All additional questions have been answered to my satisfaction by the study lead. My participation is voluntary and I am aware that I can withdraw from the study at any time, even without giving reasons, without incurring any disadvantages of any kind. I agree to the processing of the data collected for this study and I am willing to participate in the study. Hereby I confirm that I meet all inclusion criteria.

Please choose **only one** of the following:

- I agree to the informed consent
- I do not agree to the informed consent

Please note that your informed consent is required to participate in the study. If you refuse consent, the survey will automatically end.

Personal Background

Please provide some information about your personal background.

How old are you?

Please write your answer here:

What is your gender?

Please choose **only one** of the following:

- Female
- Male
- Other

What is your highest educational qualification?

Please choose **only one** of the following. If you choose 'Other:' please also specify your choice in the accompanying text field.

- Student
- Assistant
- Diploma
- Bachelor's degree
- Master's degree
- Doctor's degree
- Other

Do you have the citizenship or the center of life in a sub-Saharan country?

Please choose **only one** of the following:

- Citizenship
- Center of life
- Citizenship and the center of life

From which country in sub-Saharan Africa do you have the citizenship or have your center of life?

Please choose **only one** of the following:

- Angola
- Benin
- Botswana
- Burkina Faso
- Burundi
- Cabo Verde
- Cameroon
- Central African Republic
- Chad
- Comoros
- Congo, Dem. Rep.
- Congo, Rep
- Côte d'Ivoire
- Equatorial Guinea
- Eritrea
- Eswatini
- Ethiopia
- Gabon
- Gambia
- Ghana
- Guinea
- Guinea-Bissau
- Kenya
- Lesotho
- Liberia
- Madagascar
- Malawi
- Mali
- Mauritania
- Mauritius
- Mozambique
- Namibia
- Niger
- Nigeria
- Rwanda
- São Tomé and Principe
- Senegal
- Seychelles

- Sierra Leone
- Somalia
- South Africa
- South Sudan
- Sudan
- Tanzania
- Togo
- Uganda
- Zambia
- Zimbabwe

If you have more than one citizenship or if your center of life is in another country: Please select the country in which you are most involved with the healthcare system.

Professional Background

Please provide some information about your professional background.

Are you a working professional?

Choose one of the following answers
Please choose **only one** of the following:

- Yes
- No

What is your occupation / profession?

Please choose **only one** of the following. If you choose 'Other:' please also specify your choice in the accompanying text field.

- Physiotherapist
- Radiologist
- Speech Therapist
- Nurse
- Occupational Therapist
- Orthopedic Technician
- Orthoptist
- Physician
- Paramedic
- Physiotherapy Assistant
- Other

How many years of working experience do you have in this profession?

Please write your answer here:

Do you hold a leading position?

Please choose **only one** of the following:

- Yes
- No

Do you work in a rural or urban area?

Please choose **only one** of the following:

- Rural area
- Urban area
- Both

Are you enrolled in a course or program of study for a health profession?

Please choose **only one** of the following:

- Yes
- No

What degree is expected after graduation?

Please choose **only one** of the following. If you choose 'Other:' please also specify your choice in the accompanying text field.

- Assistant
- Diploma
- Bachelor's degree
- Master's degree
- Doctor's degree
- Other

In which medical field is your training located?

Please choose **only one** of the following. If you choose 'Other:' please also specify your choice in the accompanying text field.

- Physiotherapy
- Radiology
- Speech Therapy
- Nursing
- Occupational Therapy
- Orthopedic Technician
- Orthoptic
- Human Medicine
- Paramedic training
- Physiotherapy Assistant
- Other

Are you working as an educator to train health professionals?

Please choose **only one** of the following:

- Yes
- No

Which professions do you teach?

Please choose **all** that apply:

- Physiotherapists
- Radiologists
- Speech Therapists
- Nurses
- Occupational Therapists
- Orthopedic Technicians
- Orthoptists
- Physicians
- Paramedics
- Physiotherapy Assistants
- Other:

Which educational level do you teach?

Please choose **all** that apply:

- Assistant
- Diploma
- Bachelor's degree
- Master's degree
- Doctor's degree
- Other:

How many years of experience do you have as an educator?

Please write your answer here:

Mobile Learning for basic and further education of health professionals in sub-Saharan Africa

The following questions aim to gain insight into your own experiences, barriers, and facilitators that you have encountered or can think of for mobile learning in general in basic and further education for health professionals in sub-Saharan Africa. For this study **mobile learning** is defined as any intervention using handheld, mobile devices connected through wireless connections to deliver educational content.

Have you used, heard about, or read about mobile learning for further or basic education for health professionals in sub-Saharan Africa?

Please choose **only one** of the following:

- No, I have never heard or read of anything like this.
- Yes, I have heard or read about offers in my country.
- Yes, I have heard or read about offers in another sub-Saharan country.
- Yes, I have used mobile learning myself.

Which mobile learning program(s) have you used, heard about, or read about?

Please write your answer here:

E.g., name(s) of mobile learning program(s), from which medical field(s), for which profession

In the past 12 months, have you used any of the following to expand your knowledge about a topic from your profession?

Please choose **all** that apply:

- E-Mail
- Text message
- App on a smart phone or mobile device
- Video conference (e.g., Skype, Facetime, etc.)
- Social media (e.g., Facebook, Instagram, Twitter, etc.)
- Fax
- None
- Other:

Here are some thoughts about mobile learning for basic and further education of health professionals in sub-Saharan Africa. How strongly do you agree or disagree?

Please choose the appropriate response for each item:

	1 = Strongly Disagree	**2 = Disagree**	**3 = Agree**	**4 = Strongly Agree**
I would be worried about the data privacy if it were online.				
The course may cost too much.				
The quality of the content could be poor.				
I may not have the skills to use a mobile phone for mobile learning.				

What barriers to mobile learning for basic and further education of health professionals in sub-Saharan Africa have you experienced, heard / read about, or could you imagine being clearly relevant?

Check all that apply. Please choose **all** that apply:

- Electricity
- Internet connection
- Access to a mobile device
- Internet costs
- Language barrier
- Costs for a mobile device
- Internet quality
- Lack of time
- Lack of technical skills
- No technical support
- Other barriers:

What other barriers than those listed before could you think of?

Please write your answer here:

What facilitators with mobile learning for basic and further education of health professionals in sub-Saharan Africa have you experienced, heard / read about, or could you imagine being clearly relevant?

Please choose **all** that apply:

- Offline content
- Use of university's devices
- Use of devices from family members or neighbors
- Subtitles in native language
- Personal visits by a trained person to health professionals in their own setting
- Explanations of device use
- Other facilitators:

What other facilitators than those listed before could you think of?

Please write your answer here:

Mobile learning on digital rehabilitation for health professionals in sub-Saharan Africa

In the last section we would like to ask you about your expectations for a mobile learning unit on digital rehabilitation for aspiring and working health professionals in sub-Saharan Africa.

For this study **mobile learning** is defined as any intervention using handheld, mobile devices connected through wireless connections to deliver educational content. **Digital rehabilitation** is the use of digital technology to deliver interventions that improve a person's ability to fully participate in daily life by enhancing physical, mental, and/or social functioning.

If you use a mobile device at least sometimes to access informational materials for your studies or further education, where do you normally use it?

Check all that apply
Please choose **all** that apply:

- At public transport
- At home
- At the educational institution
- At a friend's/neighbor's house
- More outside of a building
- More inside of a building
- Other:

If you had a choice between many short learning sessions (e.g., 10-15 minutes) or fewer but longer ones (e.g., 20-40 minutes). Which option would you choose?

Choose one of the following answers
If you choose 'Other:' please also specify your choice in the accompanying text field. Please choose **only one** of the following:

- Many short learning sessions
- Fewer longer learning sessions
- A mix of short and longer learning sessions
- I do not care
- Other

How useful would you rate the following features of a mobile learning unit on digital rehabilitation?

Please choose the appropriate response for each item:

	1 = Not at all useful	2 = Slightly useful	3 = Useful	4 = Very Useful	Not important
Support of an educator during the mobile course					
Optional online contact to other participants of the same or a previous course					
Saving of the achieved progress only after completion of a submodule					
Optional subheadings in your native language					
Quizzes to consolidate the course content					
Support of an educator after the mobile course					
Video content					
Mandatory online contact to other participants of the same or a previous course					
Interactive video content					
Optional subheadings in the language of the video (English)					
Saving of the achieved progress at any time					
Video content in English					
Rather pictures than text					
Support of an educator before the mobile course					
Playable text					
Downloadable content to view later offline					

Can you think of other features that could be especially useful for a mobile learning unit on digital rehabilitation?

Please write your answer here:

Can you think of barriers that might prevent someone from participating in a mobile learning unit on digital rehabilitation?

Please write your answer here:

Imagine you are participating in a mobile learning unit on digital rehabilitation. Would you like additional classroom teaching with other participants?

Choose one of the following answers
If you choose 'Other:' please also specify your choice in the accompanying text field.
Please choose **only one** of the following:

- Yes, optional additional live classes with an educator would be nice.
- Yes, mandatory additional live classes with an educator would be helpful.
- No, I would prefer the course without additional live classes.
- Other

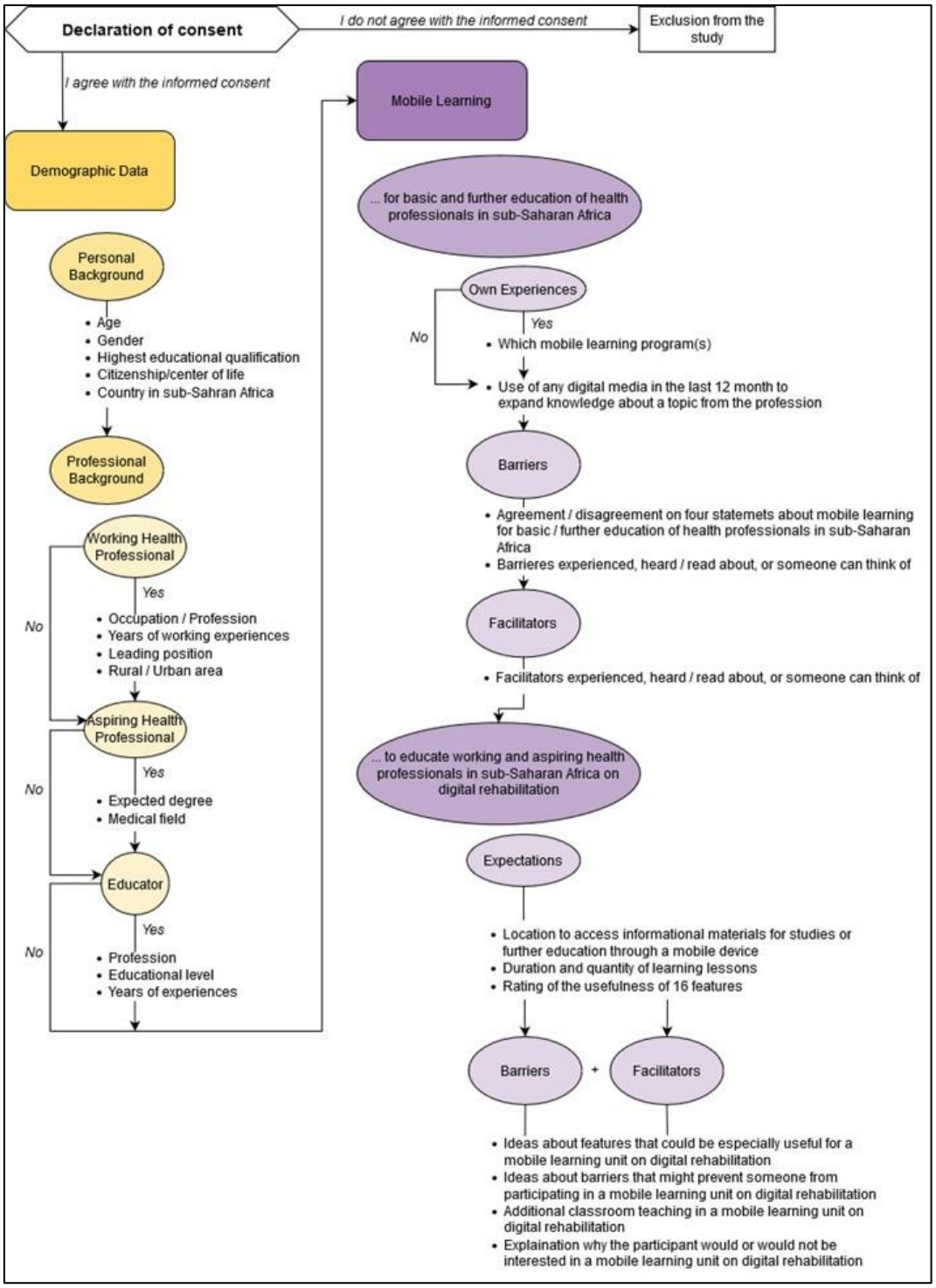
Please explain why you would or would not be interested in a mobile learning unit on digital rehabilitation.

Please write your answer here:

Thank you for your time and participation!

Your responses will help us a lot to gain better insight into the needs of aspiring and working health professionals when it comes to learning digital rehabilitation through mobile learning.

E. Detailed flow of the questionnaire



Detailed flow of the questionnaire used in the online survey. Own illustration.

F. Information letter

Needs of health professionals in sub-Saharan Africa for mobile learning on digital rehabilitation

Thank you for your interest in this survey on mobile learning and digital rehabilitation!

With this study we aim to gain insight into how mobile learning concerning digital rehabilitation should be designed for aspiring and working health professionals in sub-Saharan Africa.

The results, along with an additional literature review, form the basis for the development of a digital guidebook that will provide educators with guidelines for creating mobile learning units for digital rehabilitation in sub-Saharan Africa.

General Information

For this survey **mobile learning** is defined as any intervention using handheld, mobile devices connected through wireless connections to deliver educational content.

Digital rehabilitation is the use of digital technology to deliver interventions that improve a person's ability to fully participate in daily life by enhancing physical, mental, and/or social functioning.

This survey is being conducted as part of a master's thesis within the Erasmus+ project "Competences for the new era of user-driven digital rehabilitation" (DIRENE). The project aims to develop digital competences of teachers, students and therapists in the field of care and rehabilitation. Among other things, this is to be achieved through the development of information material on the use of digital technologies in rehabilitation. For more information you can visit the project website.

Survey process

The questionnaire takes about 15 minutes to complete.

In the following, you are asked to answer some questions about your personal and professional background, as well as your experiences and ideas related to mobile learning for basic and further education for health professionals in sub-Saharan Africa. In addition, we would like to get your opinion on how a mobile learning unit on digital rehabilitation should be designed for working and aspiring health professionals.

For some questions, you will be offered answer choices. However, there is always a free response option if none of the suggested options apply to you. For other questions, you can write down your own ideas or are asked to indicate how strongly you agree or disagree with a statement.

Your entries are anonymous. When entering data in free input fields, please avoid giving details of your own identity or information that could be used to draw conclusions about your workplace. Possible verbatim quotations in the master thesis are additionally checked for anonymity to ensure that no conclusions can be drawn about the respective persons.

If you end the survey prematurely, all information provided up to that point will be deleted. Your answers will not be saved until you have answered the very last questionnaire page.

Inclusion citeria

All participants must be

- of legal age (at least 18 years old),
- working in a health profession or be enrolled in a course or program of study for a health profession,
- and must have the citizenship or their centre of life in one of the countries in sub-Saharan Africa.

Your rights

Your participation in the study is voluntary and you may withdraw from the study and/or request deletion of your data at any time, even without giving reasons, without incurring any disadvantages of any kind.

Your obligations

As a participant, you are obliged to provide information about the above mentioned inclusion criteria (age, citizenship / center of life in a sub-Saharan country, professional background). In addition, it is important that you follow the planned procedure, read the instructions carefully and answer truthfully or to the best of your knowledge and belief.

Personal benefit

Your participation will most likely not provide any personal benefit. However, with your participation you can help us to get better insight on the needs, barriers and facilitators of aspiring and working health professionals in sub-Saharan Africa when it comes to mobile learning regarding digital rehabilitation.

Risks and disadvantages

By answering the questionnaire, you are not taking any risks or inconveniences. However, you can cancel the survey at any time. Your answers entered up to that point will not be saved until you have answered the very last questionnaire page. If you cancel the survey before then, all information entered up to that point will be deleted. You will not suffer any disadvantages as a result of terminating the survey prematurely.

Confidentiality and processing of your personal data

All data will be treated confidentially. Your data will be anonymized. Your personal data (e.g., age, gender, citizenship / center of life and occupation/profession) will be collected in a format that does not allow any conclusions to be drawn about your identity. The IP address is only used to filter out multiple votes, e.g. in the event of technical problems, so that no votes are counted twice. Please avoid giving details about your own identity or information that allows conclusions to be drawn about your workplace, even in free input fields. Possible verbatim quotations in the master thesis are additionally checked for anonymity to ensure that no conclusions can be drawn about the respective persons.

The data will be stored on a local password protected computer. Only the researcher (Nina Pietsch) has access to the full data. Only anonymized data will be used within the Erasmus+ project DIRENE. No data is passed on to third parties.

Ethical declaration

This study works towards the Erasmus+ project "Competences for the new era of user-driven digital rehabilitation" DIRENE (2020-1-FI01-KA226-HE-092634) by exploring the needs of healthcare professionals and aspiring healthcare professionals from sub-Saharan Africa in mobile learning opportunities on digital rehabilitation.

The ethics committee of the Federal State Lower Austria stated that there is no obligation for this study to be submitted to an ethics committee.

Contact person

For any questions that arise before, during or after completion of the survey, please contact the study lead:

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