Enhancing Mobile Learning in a Developing Country (Sub-Saharan Africa) Experiences in a High School in Ghana

Doctoral Thesis

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by

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ABSTRACT

This research was designed to explore the adoption of mobile devices in teaching and learning in a sub Saharan school. The main goal of the study was to investigate how new approaches in teaching and learning can be initiated in a developing African country. The research was conducted as a case study in a Senior High School in Keta, Ghana.

Because of the Central European background of the researcher, an intense literature review on the socio-economic background with a specific view on information and communication Technology (ICT) and education in sub Saharan countries was the primary emphasis. Based on the literature, lived experiences in a Senior High School were investigated.

Two main aspects were considered and compared including ICT policies in education (theoretical aspect) and what is the reality in the school. The situation is reflected in the access to resources (infrastructure and hardware and software availability in schools) and the ownership of digital devices of teachers and students at school.

Schools face major problems with inadequate ICT facilities, poor Internet connectivity, sudden electricity cut and lack of skilled teachers for integrating ICT in education. It is further reflected in teaching methods (mainly traditional, without handheld digital devices in classroom) and students' motivation to explore what is accessible online with mobile devices outside the classroom.

The study used an action research methodology, including three activity phases, performed as workshops, each with a duration of three weeks. A total of 40 teachers and 33 students from the school took part. In the time between the workshops, local developments in the school were discussed online, which was helpful for planning the follow-up workshop.

Data analysis was based on observation in the workshops, surveys (online and paper-based), interviews and developed material. Interestingly, the infrastructural challenges influenced the design of task-generation. An increased vision of how sudden power-brakes can be compensated with new ideas for STEM-related tasks, by using mobile devices in new ways developed and inspired students, teachers and the researcher with ideas for learning with mobile devices.

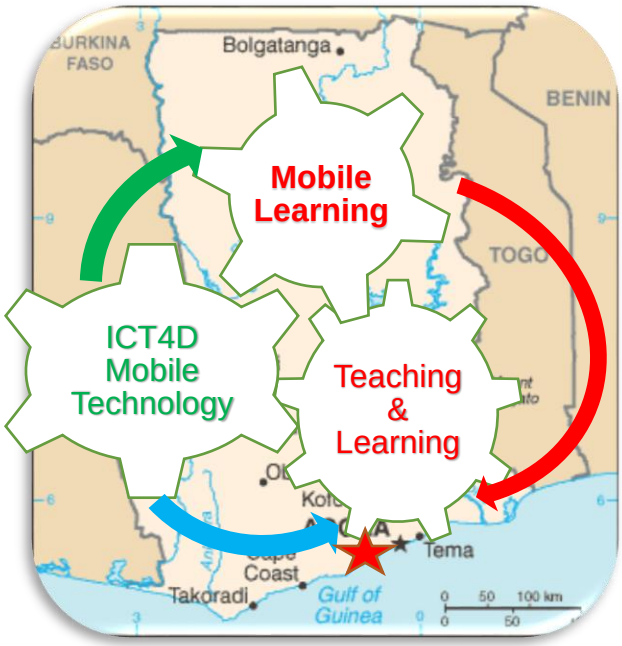
The study together with the follow up observation shows that challenges, facing the implementation of 21st century (digital) skills in a Senior High School can be compensated with incorporating teachers together with students in developments adapted to the local situation.

The findings of the study have shown that a real change in teaching and learning can be achieved when motivated teachers are willing to explore new teaching methods with integration of

mobile devices. In a first attempt teachers experienced, how digital learning material can be designed and created; in addition, didactical aspects for integration in teaching were explored. In the follow up workshops, teachers-student teams investigated how resources at the school (computer-lab) and mobile devices can be combined to support knowledge creation. Teacher-student cooperation (human resources), and hard- and software in the computer-lab together with personal owned mobile devices inspired both of them to design new tasks, for example STEM activities, and to develop study material which is thereafter accessible in the computer-lab, and online with mobile devices.

It is important to give teachers time to experiment between workshops with the gained skills in school reality. Students can help to enrich the factual knowledge presented by teachers with attempts of how actual knowledge available online, and the functionality of mobile devices, can benefit their education. Integration of online accessible quality material (Open Educational Resources) can help to develop lifelong learning skills for both, teachers and students.

Monitoring, supervision and evaluation has to be established by the authority, adequate to the local education system and environment. It also includes infrastructural support. However, establishing such 'cells' of locally relevant developments for implementing new learning and teaching activities can contribute to a better and sustainable model for development of 21st century skills than publishing ICT policies in education. This depends on the teachers and students willingness to actively take part in the development of necessary life-skills with adoption of accessible digital resources.



Mobile Learning in Ghana
Margarete Grimus

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First of all, I want to express my sincere gratitude to my supervisor Prof. Martin Ebner, and Prof. Mohamed Ally for bringing me this far. Their knowledge and commitment have inspired, challenged and motivated me.
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I wish to thank Noah Alorwu from Ghana for his activities in bringing mobile learning forward, his creativity and involvement in many related initiatives in Ghana, and for updating me continuously about the progress. Beyond that, I want to thank Michael Pollak, my co-tutor in the last phase of the on-site research.

Last, but not least, I would like to thank my family and friends for their interest in my research and work, and everyone who was involved directly or indirectly in this study

Enhancing Mobile Learning in a Developing Country (Sub-Sahara Africa)

Experiences in a High School in Ghana

CONTENT

List of Figures

List of Tables

Appendices

Files available from www.grimus.or.at

Acronyms and Abbreviations

AR	Action Research
BYOD	Bring Your Own Device
CAPS	Curriculum Assessment Policy Statement
CC	Creative Commons
EFA	Education For All
GNLE	Globally networked learning environments
GSM	Global System for Mobile communications
HDI	Human Development Index
HIV	Human Immunodeficiency Virus
ICDL	International Compute driving Licence
ICT	Information and Communications Technology,
ICT4D	Information and Communications Technology for Development
ICT4DE	Information and Communications Technology for Development and Education
ICT4E	Information and Communications Technology for Education
IRRODL	The International Review of Research in Open and Distributed Learning
LAN	Local Area Network
MDG	Millennium Development Goals
ML	Mobile Learning, mLearning
MLS	Mobile Learning Society (KETASCO MLS; group of students in Ghana)
MOE	Ministry Of Education
MOOC	Massive Open Online Course
NGO	Non-Governmental Organisation
NL, NT	New Learning, New Technology
ODL	Open Distance Learning
OER	Open Educational Resources
OLPC	One Laptop per Child
PAH	Pedagogy-Andragogy-Heutagogy
PEW	Pew Research Centre
QU	Research Question
SCORM	Sharable Content Object Reference Model
SD	Secure Digital (card)
SDL	Self-Directed Learning
SET	Science, engineering and technology programmes (in Ghana)
SHS	Senior High School
SQu	Sub Question
SSA	Sub-Saharan Africa

SSCE	Secondary Schools Certification Scores
STEM	Science, Technology, Engineering, and Mathematics
UNESCO	United Nations Educational, Scientific and Cultural Organisation
USB	Universal Serial Bus (in Ghana called pen-drive)
WS	Workshop

Enhancing Mobile Learning in a Developing Country
Experiences in a High School in Ghana (sub-Saharan Africa)

1. Scope of the Research

1.1 Introduction

The concept of mobile learning plays an increasingly important role in lifelong learning. The use of mobile devices for learning is 'no longer an innovation within institutional learning but a reflection of the world in which institutional learning takes place'. (Traxler & Vosloo, 2014, p. 21) People are using their mobile devices outside of institutions, on their own. Inside of education systems 'computer and e-learning projects have historically been constrained by hardware that is expensive, fragile, heavy and kept in tightly controlled settings'. (West & Vosloo 2013, p.7)

This particular research investigates how digital technology might benefit students in Higher Secondary Schools in a developing country in sub-Saharan Africa (SSA). The research takes into account the specific environment and infrastructure, and the needs and expectations of the participants in the region. Figure 1.1 depicts the structure of this chapter.

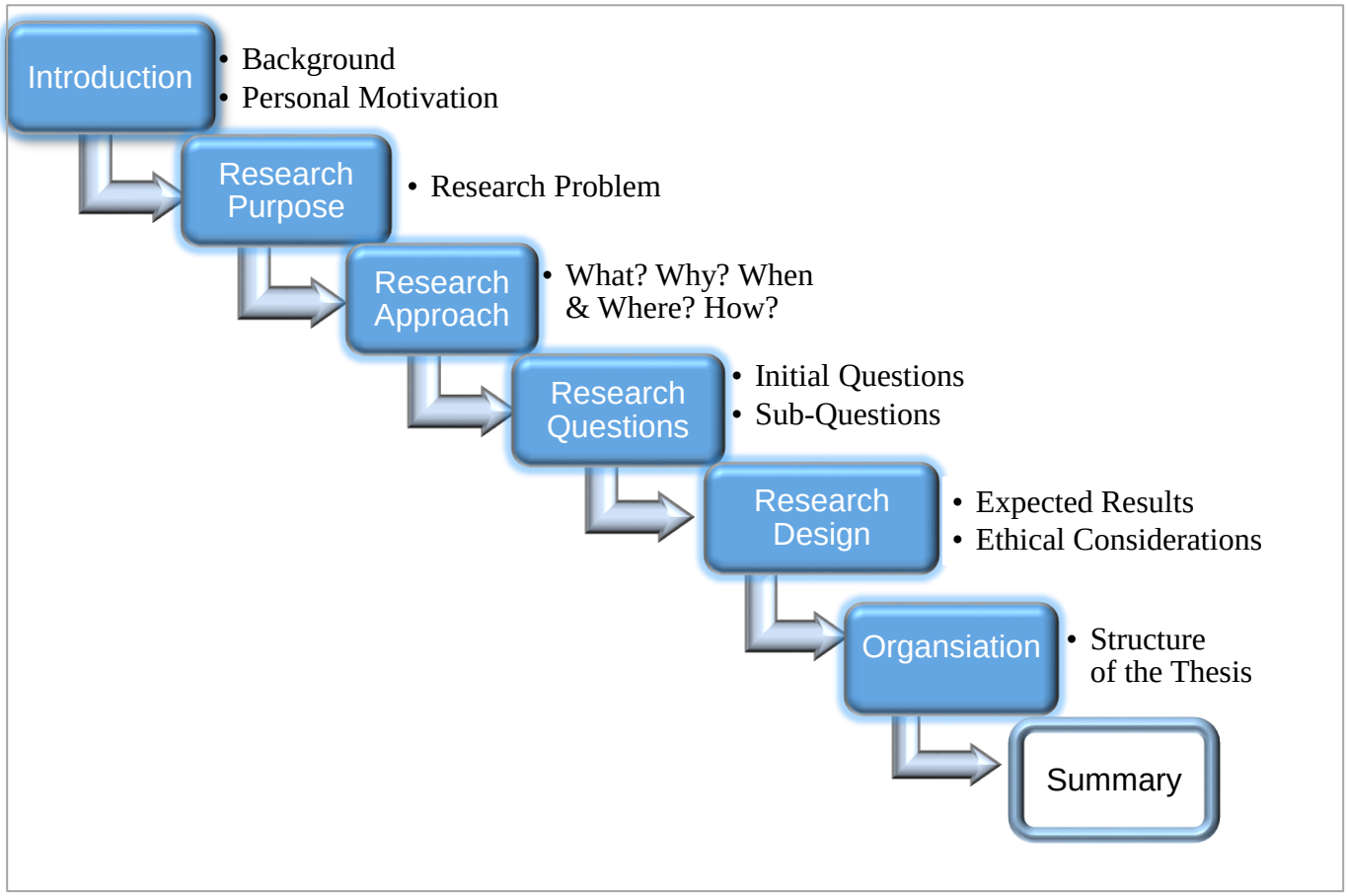


Figure 1.1 Structure of Chapter One: Scope of the Research

The focus on learning with mobile devices places this thesis within the scope of Information and Communication Technology (ICT) for development and education (ICT4DE).

Key elements of this research are education, and teachers' and students' perceptions of utilisation of mobile digital devices in developing countries.

Initial research builds on the literature, considering ICT policies in education, mobile devices for learning purposes, and the prevalence of mobile phones as a response to increase self-directed learning in Higher Secondary education.

1.2 Background of the Research

'Learning is more than just what happens in school'. (Trucano, 2014)

Access to quality education remains one of sub-Saharan Africa's most significant challenges (Dalberg, 2013, p.35). In SSA, a computer is regarded as a luxury resource. The use of ICTs that are effective for teaching students in the developed world will not necessarily work with students in developing countries (Woolf, Arroyo, Zualkernan, 2011).

On the other hand, access to information and collaboration with digital media is easier than ever before. The use of mobile technology for teaching and learning is getting a lot of attention across every sector of education around the world. Students need necessary 21st century life skills to become lifelong learners. The importance of young people in developing countries taking the opportunity to access learning material online using mobile phones is gaining worldwide interest; it is a topic in numerous international journals and conferences. According to Botha and Ford (2008), there is a need for new approaches to integrate learning with use of digital devices into the classroom, especially in African countries.

The research aims to investigate how mobile learning can be initiated independent of external support. Many programmes in Africa, developed with financial and material support from sponsors (companies and NGOs), turn out to be unsustainable after the programme runs out. In contrast to other studies, this project was set up without external funds. The main aim was to find a sustainable solution for coping with challenges that hinder increased access to actual learning material.

1.3 Personal motivation

The author's interest in the issue of ICT in education dates back for more than three decades. It is backed by long-standing experience in the field of teacher education in Europe. Based on personal expertise in designing learning concepts and working on the development of curricula for ICT integration in various European projects, I began to widen my horizon with projects on ICT in education in developing countries. My first experience in ICT in education in Africa

was gained in a project on teacher education at a private international school in Kano[1], Nigeria (2010). It was continued with investigations in Cape Town, South Africa (2010), in a workshop on development of ICT skills for people from townships; the training content was based on the modules of the ICDL (International Computer Driving License). Participants who succeeded in the final test received a certificate, which helped them in getting an employment.

In 2013, at the Eduardo Mondlane University in Maputo (UEM, the oldest University in Mozambique), I tutored lecturers on how to develop online courses for a Moodle platform provided to students of the University. My professional experience led me to put forward my efforts in establishing fruitful working relationships in other countries in sub-Saharan Africa. This research aimed to form a viable learning community to improve learning with a case study, conducted over a period of three years (2012 – 2014) in Keta, Ghana.

1.4 Purpose of the Research

The intention of conducting this research was to investigate possible interventions for promoting learning and teaching practice in a Ghanaian Senior High School (SHS). The study is based on the perception that the introduction of ICT in SHS in Ghana is in its nascent stage (Malcalm, 2012). This research considers the relevant context and investigates the complex situation in the specific area. It seeks to develop strategies for enhancements in learning and teaching in an environment where little priority is directed to computer equipment and even less to the pedagogical integration of ICT (Qingdao Declaration, 2015).

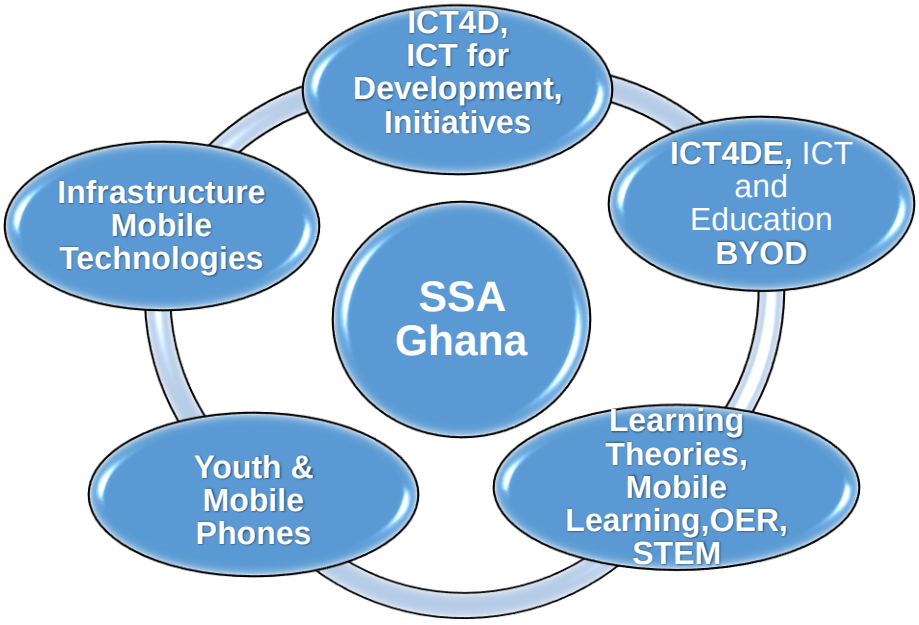


Figure 1.2 Main factors to be considered in the research

[1] http://www.mt-internationalcollege.org/index.html

The focus of this research is to investigate interventions for implementation of learning with mobile devices in the South of Ghana. The wider scope of the research is to produce knowledge that might help to gain a better understanding of how mobile phones could support students' learning in in a similar environment in other sub-Saharan countries.

Figure 1.2 emphasizes the key aspects of learning and development within ICT4D and mobile devices in the specific context (Ghana).

1.5 Research Approach

The focus of this study is the integration of mobile devices for learning in Ghana. The aim of the study was to gain insights of the local situation and educational practice in a Ghanaian Senior High School (SHS) and to investigate how learning could be improved by integrating mobile learning. Based on van Akker's idea of developing educational interventions a field study was decided in order to explore how learning might be stimulated with use of mobile devices (Akker, 1999, p. 6).

1.5.1 Statement of the research problem

Main aspects of the initial research idea are outlined in Table 1.1.

Questions	Details
What is the research about?	Investigating how mobile devices can be integrated in education in an emerging country in sub-Saharan Africa. How can mobile devices be utilised to benefit learning in a Senior High School (SHS)?
Why was the research conducted?	The research attempted to initiate a change in learning and teaching practices in a SHS in Ghana.
When and *where* was the study conducted?	The study was conducted from 2012 to 2014 in Keta; main interventions were realised in three workshops on-site.
Who was involved?	The principal of the school agreed to the study; teachers and students of a SHS (KETASCO) in the Volta region participated.
How was the research conducted?	The study is designed as action research study with three workshops: How teachers can be encouraged to develop digital content for learning purposes, and how teacher-student cooperation can affect new practice in education was investigated.

Table 1.1 Outline of the Research

Research activities focused on learning opportunities with mobile phones by deliberating requirements to be taken in consideration in order to establish a sustainable solution. Adoption of mobile devices in formal and informal learning should best meet the needs of students and teachers. The study is based on three phases of action research.

The research was guided based on elaborating on the following research objectives in order to develop an appropriate solution:

- to investigate the local environment and infrastructure,
- to identify influencing factors for launching learning with mobile devices,
- to understand the particular context and interplay of school-related factors (e.g. teachers' digital literacy, regulations on the use of mobile phones),
- to learn about students' perceptions of actively participating in new developments in cooperation with teachers.

The research problem investigated within this thesis reads as:

- How can current practice in SHS be improved by using mobile devices to prepare students for 21st century demands?
- What are the preconditions and necessary requirements for enabling mobile learning?

1.5.2 Research Questions (Qu)

The above-outlined research problem is summarised in two preliminary research questions, as a starting point for this thesis:

Qu1: What are the most important issues to consider when planning the integration of mobile technologies in learning and teaching in a developing country in sub-Saharan Africa?

Qu2: How can mobile learning be initiated as a beneficial supplement to education in a Senior High School in Ghana?

This study topic arises from limitations in access to computers and Internet and is directed to improve learning opportunities by using digital devices in two dimensions, which are reflected in two sub-questions (SQu):

SQu 1. How can teachers be encouraged to integrate new pedagogical attempts, including mobile learning activities, in their daily practice?

SQu 2. How can students assist in improving teaching and learning practice through integration of mobile devices for learning in a traditional school system?

1.6 Research Design, Overview

Conditions for using digital technologies in teaching and learning were investigated over a period of three years. Preliminary insights into the diverse influencing factors were gathered by literature review.

The research was conducted in cycles, dividing the principal problem into manageable sub-sections. The research context includes the following primary settings: first, a literature study on ICT4D in sub-Saharan Africa and mobile learning (Chapter 2); secondly, on-site research, consisting of three workshops in Ghana (Chapter 4); and finally, discussing and theorising based on the findings (Chapter 5).

Aim of the study

Determining how mobile learning can help students to bridge learning gaps and minimise the digital divide by facilitating use of mobile devices under the conditions of a developing country.

Time and location

The researcher, from Central Europe, worked with local participants between 2012 and 2014, conducting three workshops (each of three weeks duration) in Keta, Ghana.

Participants

40 teachers and 33 students (16 -20 years of age) participated voluntarily in the workshops; other students and teachers on the campus contributed with statements in informal discussions.

Methodology

The study was conducted by means of action research with observations, qualitative interviews and questionnaires (quantitative and qualitative). Different data collection methodologies were used in organising, collecting and interpreting data systematically, before continuing with the subsequent cycle.

1.6.1 Anticipated Outcome

The aim of this research was to create a deeper understanding of how cooperation of teachers and students in developing study material can shape teaching and learning practice. The researcher expected results that can help to understand how learning with mobile devices can disseminate with young learners, and teachers' perceptions of how this can contribute to shifts in pedagogy in Higher Secondary Schools. The goal of this research results in recommendations for the integration of mobile learning activities in Higher Secondary schools in sub-Saharan Africa under similar conditions.

The results of this thesis demonstrate the potential of a mobile learning intervention in higher education in a developing country. The outcome contributes to the knowledge base for utilisation of mobile devices for learning purposes by providing insights into following aspects:

- Identifying supporting factors and barriers for initiating mobile learning in higher education in a developing country.
- Providing examples of how students can be incorporated in the development of locally relevant content to stimulate new learning practice.
- Strategies for coping with limited digital resources (scarcity of computers, hardware and software) and lack of Internet connectivity are demonstrated.

Examples of how teachers can be encouraged to develop pedagogical skills for integrating mobile devices in the learning process are presented; participating teachers can act as role models for their colleagues and disseminate newly gained expertise.

The study provides means to encourage school staff to open education practice in the sense of self-directed learning. This can motivate teachers to harness digital technology for upgrading teaching and learning practice. Furthermore, the results aim to attract the interest of stakeholders and researchers to implement similar models in other regions of sub-Saharan Africa.

The research includes a final report (thesis), presentations at international conferences and publications in peer-reviewed journals.

1.6.2 Ethical considerations

Local and social context, religion, local custom and didactical peculiarity are specific dimensions of culture and influence knowledge transfer (Wells & Wells, 2007). In this study, the researcher is not organic to the research environment, but she is offering an intervention for mutual benefit in education in a Ghanaian school. During the on-site phases, the researcher lived on the campus in order to build trust and confidence among the population involved in the research. Most obviously, it could not be guaranteed that the research, i.e. intervention and time schedule, did not influence the participants' common daily routines, although participation in the workshops was voluntary for both teachers as well as for students.

This research aimed account for these characteristics by considering individual interests and rights, particularly with respect to principles such as voluntary participation and anonymity; online surveys were conducted anonymously. All participants agreed on distribution of developed material, images and photos in academic writings and journals.

1.7 Organisation of the Thesis

Based on a concept provided by McKenney and Reeves (2012, p. 186), this thesis is organised as follows. The study begins with an introduction to the main issues contextualising the research problem, outlining the objectives that motivated this study (Chapter 1).

In Chapter 2, the background of the study is explained. The literature review of the research area includes a wide spectrum of issues and conditions specifically related to the sub-Saharan

African context, in order to underpin the relative position of the research. General factors influencing the integration of ICT in education with a specific focus on Ghana are depicted. It includes topics such as ICT for development and education in cultural context, educational policies, former ICT initiatives and other interrelated issues in ICT integration. Additional sections underpin the issues of learning and pedagogy, since they affect attempts at mobile learning and are related to demands in developing countries. For example, youth and their perceptions of mobile phones for learning purposes have an impact on developments in education in developing countries. (Chapter 2)

Based on the literature review, as mentioned above, the author briefly outlines the research design and the rationale for choosing a specific methodology in the third chapter. The intention that constituted the decision for choosing the conceptual framework of Action Research is explained. (Chapter 3)

In the subsequent chapter, the process of the research study is outlined. On-site studies are documented in detail, including structure, topics and content, and outcomes of the workshops. Topics addressed are the particular study phases, underpinned with examples of tasks and developed material, data collection and data analysis, and strategies and reflections of the respective research cycle. (Chapter 4)

In the fifth chapter, the author elaborates on the findings obtained in the process. This chapter demonstrates the interplay between formal and informal learning with mobile devices. Perspectives on the acceptance of mobile learning interventions and transformation of teaching practice are outlined. Topics are discussed and theoretically underpinned. The chapter is based on information, e.g. on governmental directions, reflections on success, and limitations achieved in the consecutive cycles of the research process. (Chapter 5)

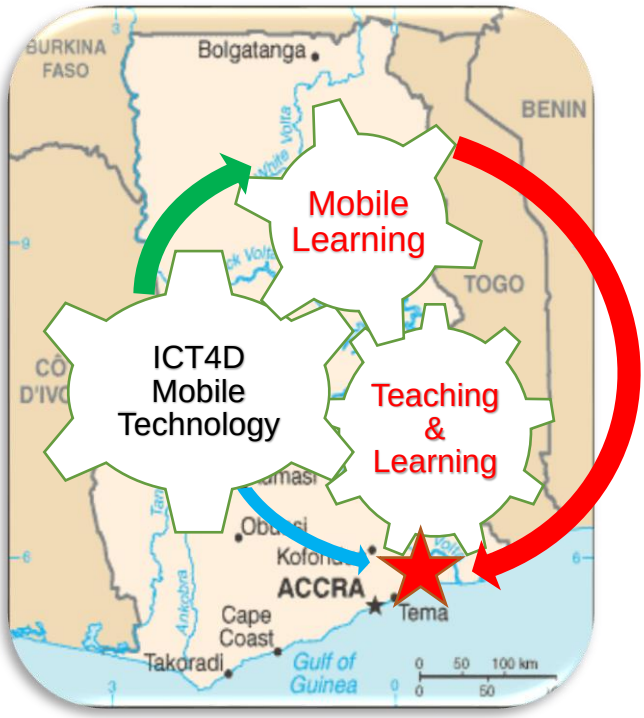
This thesis concludes with a summary of the research findings pointing out the most important issues for approaching new learning practice in a sub-Saharan African country. Recommendations for potential directions of further research on mobile learning applications and activities derived from the research are depicted. Conclusions regarding the research questions in this study are drawn. (Chapter 6)

1.8 Summary (Chapter 1)

This chapter provides an introduction to the research study. It outlines the aim of the study, namely understanding how education in a Senior High School in Ghana can be improved by the use of mobile devices.

In this chapter, the purpose of the research, background and personal motivation, research approach and design, significance of the study and expected outcome of the research are elaborated. The background of this dissertation is thus established.

In the next chapter, background literature with regard to the specific research context in sub-Saharan African countries is explored. Firstly, a deeper insight into relevant factors influencing ICT developments and education in sub-Saharan Africa is presented. A focus is directed to learning and education in general, and specifically on opportunities and barriers for using mobile phones for learning. Finally, specific related issues in the Ghanaian context are explored.



Ghana, intertwining aspects.
Keta, location of the school.

2. Literature Review in Context of the Study

2.1 Introduction

Marshall and Rossman (2011) underscore the relevance of a literature review in setting up a research study, stating that it provides a structure for establishing the importance of the study. The scope of the literature is relevant in order to underpin the research problem and to provide better understanding of the purpose of the research.

In this chapter, an overview of the most important bodies of literature on the theme of the thesis is provided in order to reveal the research problem. This review is of particular importance, as the author lives in central Europe and was not familiar with the political, ethical and cultural traditions of sub-Saharan Africa. The literature frames the problem, supported and guided the implementation of the study, and finally underpins findings, which impact the study.

This research started with a fundamental literature review to develop a foundation of background knowledge on the topic of Information and Communication Technologies (ICT) and learning in developing sub-Saharan African (SSA) countries. The intention of this literature study is to provide deeper insight into the complexity of ICT and development (ICTD), and into education in the sub-Saharan African context, based on recent publications (e.g. conference reports, journal articles, books, theses, statistics).

Avgerou and other authors draw attention to research on development in combination with the impact of ICT, because it addresses a multidisciplinary field in developing countries. It is essential to consider how socially embedded ICT innovations are affecting values and infusing behaviour of a national culture and changing socioeconomic conditions in developing countries (Avgerou, 2010, p.15, Heeks, 2007). It furthermore underscores the importance of considering cognitive, emotional and political concerns, and what is locally meaningful, desirable or controversial.

A wide range of literature on knowledge of ICT dissemination with regard to governance, democracy and education in SSA provides a bounding frame of the research.

The present study attempts to reflect on issues relevant to developing strategies for the integration of new learning opportunities using mobile technology in Ghana. This requires deeper knowledge of the acceptance and use of ICT, for example with respect to teaching tradition, infrastructure and equipment in schools, in order to contextualise the research and to draw conclusions from the findings.

The most important domains to be considered in this study on ICT for development and mobile learning are education and learning, policies, infrastructure, and youth and mobile devices. The structure of the literature review further guides the reader to integrated sub-topics of the study.

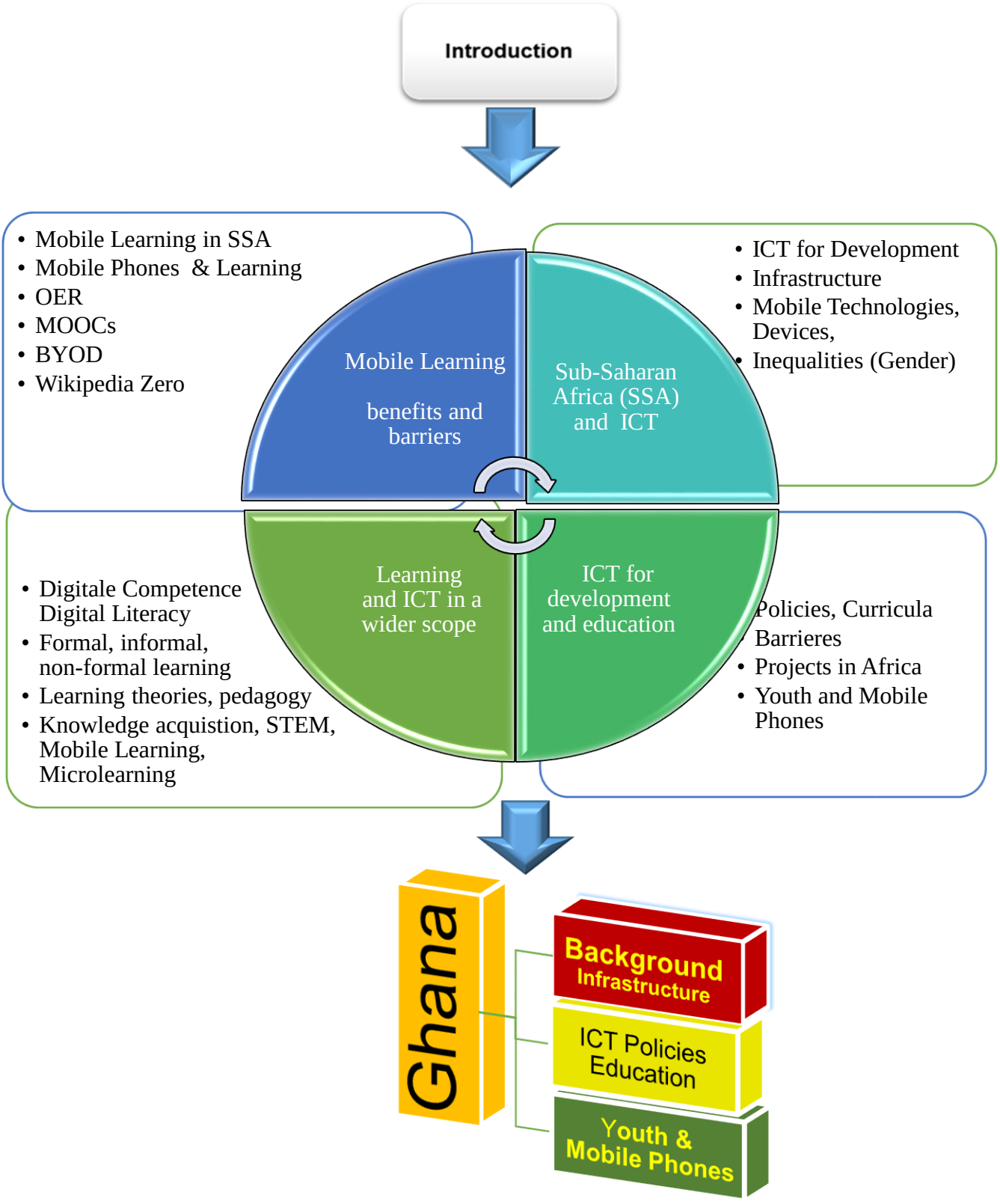


Figure 2.1 Main topics and integrated sub-topics of this literature study (Chapter 2)

Figure 2.1 illustrates key ingredients and related issues framing this research. Based on the literature review, preliminary research questions were formulated (see 1.5.2). These questions were refined in subsequent stages of the research (see 5.2).

In planning this research project and preparing follow-up stages, insights into various issues helped to ascertain the variety of interrelated aspects involved in the development of ICT in emerging states, in general and particularly in education. Because many sub-Saharan African countries face similar demands in education, which are very different from the rest of the world, the background information of this study might also provide insights that could be useful for further research in the region.

In this chapter, after a general overview of related topics in the context of sub-Saharan Africa, emphasis is placed on the situation in Ghana, where the project was carried out.

2.2 Sub-Saharan Africa

Sub-Saharan Africa (SSA) refers to 48 of the 54 African countries. (Figure 2.2) The region is extremely diverse in terms of population, size and political systems, and in terms of levels of development in economies and education. The population of SSA was estimated to be 1,000,980,000 in 2015, having climbed from 228,268,750 in 1960 [2].

SSA is still termed the poorest region in the world. According to World Bank data, 42.7% of the population lived below the poverty line ($1.90/day) in 2012 (WorldBank 2014). 28 states in SSA hold the last 30 positions in the Human Development Index (HDI, 2015).

It is the area with the most linguistic diversity of any region, with estimated 1,500 - 2,000 spoken African languages. [3]

Atanga et al.(2012) characterise sub-Saharan Africa in context with 'cultures of orality, multi-lingualism / multi-ethnicity, respect for the elderly, the importance of religion, strong family networks, often salient gender differentiation, stark gaps between rich and poor, and sharp juxtapositions of the traditional and the modern', and is 'supplemented by characteristics of relatively recent colonialism and post-colonialism'. (p. 4)

South Africa plays an important role as the most developed country; some mobile learning activities and scientific publications on the topic of this study have their roots there.

Diverse histories and education systems within countries and across national boundaries result in an enormous variety of problems in the region. The majority of the African states decided after their independence to use the European languages English, French or Portuguese, introduced by the colonial powers, as official national languages.

English is the official language for 470 million people in African regions. However, a high percentage of African citizens (approximately 20%, predominantly female) are still not able to understand and to speak the official language in which their home country is governed and

[2] http://data.worldbank.org/region/sub-saharan-africa

[3] http://www.nationsonline.org/oneworld/african_languages.htm

administered. (WorldBank, 2014) Consequently, the diversity of spoken languages is one of the severe problems for raising educational standards in SSA. Although there has been significant progress in increasing adult literacy rates across SSA in recent years, approximately 37% of the adult population still lacks basic literacy skills (GSMA 2014, p.35).

The geographical situation of sub-Saharan Africa is depicted in Figure 2.2. [4]

Figure 2.2 sub-Saharan Africa, Ghana

2.3 ICT for Development (ICT4D), Infrastructure and Digital Divide

ICT influences several aspects of a society, e.g. educational development, economic growth, social awareness, cultural enrichment and political leadership (Tedla, 2012, Dzidonu, 2010, Kozma, 2005; Unwin, 2005a, UNCATAD 2011).

Note that official papers use the term ICT generally for research and integration of digital technology as a factor for development, without specification of devices, mobile diversification

[4] Image -Source: Wikimedia Commons, https://commons.wikimedia.org/wiki/File:Subsaharanafrica.jpg Ghana tagged by Margarete Grimus

and so on. Although this research addresses integration with mobile learning, the term ICT is used as an overarching term in this paper.

ICT for Development (ICT4D) is an emerging research area, examining how the use of ICT can assist to achieve societal development, particular addressing health, education, enterprise and rural development (Kleine & Unwin, 2009, Thapa &Saebo, 2014).

Connectivity has an impact on the digital divide; it is closely related with Internet use and quality of access. An infrastructural deficit associated with the level of illiteracy poses great challenges to the educational and general development in Africa (Osang et al, 2013, Wright, 2014).

The Internet penetration rate in African populations is 28%, the lowest of any world region, e.g. compared to Europe with 73.9%, and North America with 89.0% penetration; the growth rate from 2000 to 2016 counts for 7,288 % (no typo!) in SSA. (ITU 2016, Internet Users in the World Region by June 2016, Internet World Stats 2016)[5]

Kai-Ti Kao (2013) considers ICT4D as an effective approach to socio-economic and human development. He points out that ICT4D is offering solutions to help to bridge the digital divide.

However, many regions in SSA lack electricity and Internet connectivity, which are barriers to access digital learning tools. As stated by Unwin, 'the digital divide is very much expressing itself across Africa as a bandwidth divide'. (Unwin, 2005b, p. 123)

The McKinsey Report 2013 refers to the willingness of governments to embrace openness and to provide increased access to public information via the Internet. However, beyond simple access, skills, values and context as well as the content of digital material are very important.

2.3.1 Mobile Networks and Devices

According to GSMA, landline penetration across SSA is only 1.3%, the lowest of any region in the world (GSMA 2014, p.29). Whereas access to a fixed landline has remained static for a decade in Africa, access to mobile phones has grown exponentially in the past few years (PEW Research 2016).

Mobile technology often represents the first modern infrastructure of any kind in Africa. Mobile networks have become the predominant infrastructure across SSA, with more people now covered by mobile networks than have access to energy and water (GSM 2014).

Instead of starting with traditional fixed-line solutions and use of desktop-computers, developing countries leapfrog to wireless technologies. Bhagavan (1990) describes leapfrogging as a method by which developing countries are using the power of new technologies to transform vast areas of economy in relatively short periods. Fong (2009) refers

[5] http://www.internetworldstats.com/stats.htm , accessed Dec. 2016

to leapfrogging 'as the adoption of advanced or state-of-the-art technology in an application area where immediate prior technology has not been adopted.' (p. 3707) Mobile-based solutions have emerged as a leading leapfrog technology in developing countries and can help to compensate the lack of landlines and provide access to educational material for all. They offer better and less costly access to the Internet and are often the only infrastructure in remote and rural areas. Mobile devices can extend, enhance, enrich, and challenge existing ideas and assumptions about learning in the environment of the research area of this study.

The PEW Report (2016) revealed, that people in developing countries confirm that the increasing use of affordable devices (cell phones) offers the chance to overcome the worst infrastructure challenges. Mobile Internet has the unique effect of helping to reach people in the remotest areas and giving them access to the kind of support and structure that can enable them to improve their livelihoods and move beyond subsistence living (inet-Report 2015, p 74).

In most SSA countries, mobile phones are nearly universal, and smartphone ownership rate is skyrocketing (PEW Research, 2016). 'The cell phone is the single most transformative technology for development'. (Etzo & Collender, 2010, p.661) These devices are the chance for the African population to skip the landline stage and jump right into the digital age. However, in terms of costs of devices and mobile services, there exist major inequalities across countries. Interestingly, according to PEW report 2016, in the developing world Internet users are using social networks more frequently, as compared with US and European Internet-users (PEW Research 2016).

2.3.2 Youth, Mobile Phones, SSA Perspective

As outlined in the previous sections, increasing access to mobile phones is a powerful driver for access to learning material. Young people's use of mobile phones has expanded exponentially across SSA in both urban and rural contexts, and has become an integral part of their daily lives (Porter et al, 2016). Mobile phone manufacturers now offer low-cost smartphones to emerging markets, and costs for data-plans are declining (Dzidonu, 2010).

Mobile phones have changed how youth communicate, gather information, and share knowledge, and can change learning when used appropriately. Mobile learning is encouraged by the new ways in which youth use mobile phones. Students usually search for information on the Internet when they need the information; they want the information right away. Smartphones provide remote access to information and enable social interactions among students. They support a variety of activities such as discussions (with peers), exploration and investigations (environment), recordin*g* of data (sounds, images, videos, text, locations) and sharing of captured data (Laurillard, 2007). Smartphones encourage reflection and collaboration during learning phases.

Results of research from SSA emphasize that younger learners are more comfortable with using mobile phones for learning (Oyerinde, 2014). This generation has triggered the fundamental

transformation in the education sector. Schools are forced to adopt mobile learning and digital tools to keep education relevant and young students engaged. Dawes ascertains in her research that the highest level of access to a mobile phone amongst young people in four African countries was found in 2011 in Ghana, reaching 90%. (Dawes, 2011) According to PEW research (2015), younger, educated and English-speaking Africans are more likely to own a smartphone. Porter et al. (2016) conducted field research in 24 sites across Ghana, Malawi and South Africa. They state that 'the smart phone is now an essential accoutrement of 'cool' youth, whether they are rich or poor.' (p.23)

Young people value their phones and are likely to take good care of their devices. They carry their phones with them at all times, so learning can take place anywhere. It offers the possibility of phone use in educational contexts, which should be suggested as a better alignment of practice and policies. Thus, poverty does not seem any longer to be a limiting factor for using mobile phones as a cognitive tool for knowledge creation in learning tasks, it seems more to be a demographic digital divide. (Fullan & Langworthy, 2014)

Porter et al. (2016) further argue that – besides the potential of expanding students' learning opportunities – mobile phones help 'to give students voice and agency as they explore their place in the world.' According to UNESCO, youth use social media extensively with their mobile phones, as a 'space for self-identification, self-assertion, contestation and mobilization around democracy, human rights and civil liberties'. (UNESCO 2012, p. 6)

2.3.3 Inequalities and Gender

A challenging gender gap is recognised, as women have lower language and digital literacy rates across SSA than men (GSMA 2014, p.35). A gender divide exists in all of the SSA countries: men have greater access to the Internet, for example in Nigeria, 48% of men say they use the Internet versus only 29% of women; Kenya, Ghana, Tanzania, Burkina Faso and Uganda also report a double-digit percentage gap (*i*net Report 2015, p. 4; ITU 2016). A serious gender gap is also reported in smartphone ownership. Women, the less educated and those who cannot read or speak English are less likely to own a smartphone. As outlined above, in Nigeria and Kenya, men's smartphone ownership is 12 % higher than women's are. Other gaps exist with respect to age, education and income. People with more education and higher income are more likely to use the Internet or own a smartphone. Gaps in level of education can rise to more than 50%, as reported from Burkina Faso and Kenya (PEW Report 2016). In order to tackle the high cost of mobile Internet subscription relative to income, many people share a subscription with others.

2.4 ICT, Development and Education (ICT4DE)

Education plays a fundamental role in social and economic development, and is a priority area for development in most sub-Saharan African countries (Dzidonu, 2010; HDI, 2015). Education

in SSA lags far behind other regions (McKinsey Report 2013, Majgaard & Mingrat, 2012). Education systems in SSA 'face endemic crises under the influence of widespread poverty, inequality and political regimes that range from dictatorships to democracies'. (UNESCO 2012, p. 7) Improvements in education and increased access to ICT are two prominent objectives of the Millennium Development Goals (MDG).

Most African countries are operating with limited educational resources and at the same time, facing increasing demands for educational services. In SSA, students have limited access to up-to-date textbooks and instructional material. Thus, the African population is striving for improvement and personal growth, raising a booming demand for education systems. Student populations in Africa continue to grow, causing demand for better learning conditions and quality of education at all levels of the educational system 'This includes supporting literacy education for a larger population and increased access to higher education (WorldBank 2011, and 2014).

Because the demand for education in Africa continues to increase relentlessly, it 'raises the need to identify more affordable ways of improving access to learning opportunities.' (Osang et al, 2013, p.1) 'ICT has the power to unlock doors in education'. (UN Secretary-General Kofi Annan, cited by Wagner, D. [6])

The Education for All (EFA) and the Millennium Development Goals (MDG) aimed to ensure quality education to achieve universal primary education. Policymakers in SSA have focused on primary and secondary education as the key to development and poverty reduction. Internationally raised funds have addressed improvements in access and attendance to basic education. Henessy and Onguko (2010a) indicate that the challenges in higher education are ironically related to the MDGs, by addressing free universal primary education, but higher education was not in the focus of EFA in SSA. (p. 67)

Only 6 % of young people in SSA are enroled in higher education institutions, compared to the global average of 26 %. (Africa Report 2015, p.10) The limitations for entering tertiary institutions result in low research output in African countries. Almost all universities in sub-Saharan Africa use European languages, which, in almost all cases, are not the students' mother tongue. In contrast to the scarcity in education, there is much educational content in English, French, Portuguese and Spanish available via the web, which could be beneficial for personal development.

A possible link between the pervasiveness and utilisation of ICTs and the economies of African countries is outlined in the report on the achievement of the Millennium Development Goals (Dzidonu, 2010). In SSA the acquisition of knowledge and skills in ICT (e-literacy, digital literacy), with major economic and employment consequences in today's technology-driven

[6] https://www.infodev.org/infodev-files/resource/InfodevDocuments_290.pdf, p.1

world, becomes very important. Changing requirements in the type and level of knowledge, skills and competencies for today's knowledge-based economies, combined with insufficient opportunities to access higher levels of learning, are resulting in a knowledge divide. (ibid) Currently, increasing interest in higher education, as part of the post-2015 development agenda, puts pressure on educational reforms to support the growing numbers of students: 'The spread of ICT use in jobs is one reason why schools and students are eager to be proficient in ICT'. (WorlBank2011, p. 72) Integration of ICT is an opportunity for tackling educational challenges, to improve the quality of teaching and learning, it can also expand access to learning material. (UNESCO 2012)

Systemic failures are caused by traditional education delivery, lack of trained teachers (one million need to be recruited for primary education alone, according to Africa report 2015 (p. 11) and the demands to increase the scope, scale, quality and equity of education.

Dzidonu (2010) and Selinger (2009) refer to the viable role that ICT plays in reforming education systems, by increasing access to resources, improving the management of education and enhancing pedagogical methods. Frempong emphasises that there is much promise in the use of ICT in education, although a widespread ignorance of the specific impact of ICT on education goals and targets exists as well. (Frempong et al, 2015) Mobile technologies are deemed having the potential to promote and to transform teaching and learning processes; mobile devices are looked upon as tools for exchanging and cooperating in learning processes and for gaining knowledge in authentic context (MoLeNET infoKIT[7] p. 23).

Winters (2015) discusses rationales for the use of technology in teaching in Africa as too simplified. He points out that they need

- to provide students with the skills they need to take part in the knowledge economy of the 21st century,
- for teachers to improve their teaching practice, and
- as a means by which self-guided informal learning will flourish.

Adapted from Winters 2015, p.47

Winters further refers to the importance of the educational perspective, mainly that mobile learning initiatives require the skills of teachers (based on teacher training and classroom-experience). He states that mainly techno-centric or solely content-based solutions will not solve educational key-challenges in Africa. (ibid, p.48)

Improving the quality of education would benefit millions of young people in Africa. UNESCO contributed to the issue of ICT integration in developing countries with a series of studies, consultations and policies on ICT in education (UNESO, 2013).[8].

[7] https://mobilelearninginfokit.pbworks.com/w/file/fetch/50760424/mobile-learning-infokit.pdf (no date)

[8] (UNESCO http://www.unesco.org/education/mlearning-resources).

The Internet's transformative potential in Africa is outlined more detailed in the McKinsey's publication 'Lions go digital'. (McKinsey Report 2013).

2.4.1 National Policies in Education

It is common sense that addressing challenges requires a range of interventions. In most sub-Saharan African countries, national policy programmes were developed for guiding investments in ICT. Utilising the potential of ICT at all levels of their educational systems aims to transform learning and the relationship between school systems and society (PEW Report 2016).

'The capabilities of new technologies can help policy-makers respond with needed changes in curriculum, pedagogy, assessment and social organisation.'(Kozma 2011, p.21)

Culture influences traditions in education by shaping values and norms. According to Somekh and Zeichner (2009), 'digital technologies import ideas that transgress the boundaries of traditional culture'. (p.6)

There is a great deal of variance in ICT policies for education among the African countries. Mathipa and Mukhari (2014) refer to the reason that in developing countries 'the use of ICT is considered as a foreign idea and borrowed policies' They continue that these borrowed ideas are very often simply adapted and integrated into national policies. (p.1216) Promising educational policies often turn out to be unrealistic.

Very often, there exists a policy on ICT integration in education, which does not reflect the real situation and cannot be transformed into action because of a lack of in-service training. Therefore, in many cases, it turns out that these attempts are impractical and finally fail. Despite the increasing popularity of the Internet and emerging educational technologies, apathy, resistance to change and negative attitudes inhibit integration of ICT to facilitate education in many African educational institutions (Dzidonu, 2010).

Many schools with equipped computer laboratories are struggling with their effective use. Although the potential value of ICT in education is recognised, many countries face significant challenges in transforming the promises of technology into benefits for education (Kozma, 2011; Mathipa & Mukhari, 2014). 'While the policies are highly ambitious, the limited evidence available of their implementation indicates that their status remains largely at the level of rhetoric in some countries and in some aspects'. (Hennessy, Onguko, Ang'ondi, Harrison, Namalefe, Naseem, Wamakote, 2010, p. 96)

Their opinion is even extended by Henessey et al (2010), who further argument: 'When new political leadership takes over through elections or other means, then previous commitments tend to be thrown out of the agenda'. (p.35) Thus, very promising policies of adoption and implementation of ICTs in education 'remain as a mere policy'.

Tedla (2012) suggests that policy makers 'should target and integrate ICT into a curriculum with an account of economic, cultural, political, social, educational and catalytic rationales' […and] 'develop a broad ICT integrated curriculum at all levels of education.' (p. 203, p. 206)

2.4.2 Curricula

In many SSA states, ICT is not part of a general curriculum, rather just a separate subject (Tedla, 2012, Dzidonu, 2010). Hennessy et al. (2010a) indicate that 'ICT curricula mainly focus on teaching students about technology, not how they can apply that technology to enrich learning'. They further determine that, even when 'students are taught basic computer skills and applications -predominantly word processing, spread-sheets and Internet-but are not taught how to use ICT as a tool to facilitate learning in other areas'. (ibid p 65, see also Figure 4.10 in Chapter 4)

2.4.3 Inhibiting Factors for ICT Integration in Education in SSA

Various factors directly or indirectly affect the integration of ICT in education (UNESCO 2012). Serious obstacles oppose the potential of the Internet for education, e.g. access to reliable networks, cost of connectivity and ICT services, and intermittent power disruptions (Dalberg, 2013, MDG 2015, Diallo, 2014, Mathipa & Mukhari, 2014). Given the important role that ICT plays in the delivery of educational services, the poor infrastructure in most African countries is a major obstacle for expanding educational and training opportunities (Hennessy & Onguko, 2010, Mathipa & Mukhari, 2014; Tedla, 2012). Additional challenges are low levels of literacy, extreme poverty, increasing instances of HIV affecting the availability of teachers, and a lack of political will to alleviate the situation through proper planning (Hennessy et al, 2010a, p.56).

2.4.3.1.. External barriers and school characteristics

Effective application of ICT in daily school practice relies heavily on the availability of technological resources. Many African countries do not have funds to sustain the use of ICT in their schools. Besides the lack of basic infrastructure, assistance and support, functioning computers, equipment maintenance and computer lab space are main obstacles (GSMA-Kearney, 2011, GSMA 2014, Tedla, 2012, Dzidonu, 2010, Malcalm, 2012). In SSA, most computers in schools are of poor quality (refurbished computers, out-dated technology); often they are donations from businesses. This becomes a burden to the schools within a short time, because of very short working life remaining.

Mathipa and Mukhari (2014) argue that teacher salaries usually consume state funding to schools; this makes it difficult for public schools to generate resources to set up the necessary infrastructure.

Michele Schweisfurth (2013) refers to formulations in policies, which can either be difficult for teachers to understand, or the process for implementation is not supported in different parts of the system (p. 4). She continues by stating that teachers often see policies as contradictions to

promote learner centred pedagogy, 'when high-stakes examinations which test fixed knowledge drive teachers', students' and parents' motivation'. 'Teachers will teach to examinations to meet students' needs and to protect their own reputation'. Future education and careers depend on examination results, whereas learner-centred strategies are considered a luxury. She refers to further challenges, ranging 'from poor infrastructure to corruption' and to the 'prioritisation of survival needs'. (p.4)

2.4.3.2.. Internal barriers, regulations, leadership

Internal barriers are a lack of qualified and confident teachers, institutional rules and regulations, and poor school vision and mission. If school leaders have a negative attitude toward computers and the Internet, they do not prioritise access and connectivity (Ndidde et al, 2009 p.66; Hennessy & Onguko, 2010a, p.64). In developing countries, cultural roots shape and interact profoundly with teacher-learner relationships and classroom behavioural norms (Schweisfurth, 2013).

Dzidonu (2010) argued that teaching approaches remain basically unchanged in most schools. He says that technology is poorly adopted and underused in classrooms. Tedla (2012) corroborated that there is a common misconception, namely that the availability of computers in schools itself is enough: The presence of computers alone is insufficient to affect students' learning and unlikely to promote educational change.

Beyond ICT use for students' learning depending on access to computers and devices, locked doors often limit access to the computer-lab, as school directors try to ensure the security of equipment. When computers are used on only special occasions, they remain an object of curiosity rather than being seen as the useful tool that they can be.

Mathipa and Mukhari (2014) state that only some African private schools provide free access to the Internet for their students. (p. 1216)

2.4.4 Teachers' Roles

Integration of ICT to enhance teaching and learning to raise educational standards depends on teachers. Teacher capacities are defined as a 'combination of competencies, motivation and the characteristics of teachers' working environment'. (Qlan Tang in Kozma, 2011. p.1) Teachers beliefs, acceptance, readiness to use new technology and pedagogical expertise are the keys to effectively implementing curricula and using ICT (Hennessy et al, 2010b, p.42-46; Oyerinde, 2014; Dzidonu, 2010; Osang et al, 2013; Wright, 2014).

Teachers in SSA are often untrained or undereducated; many teachers are expected to work in a language of instruction – usually a colonial language – in which they are not comfortably fluent (Hardman et al, 2009). Little or inadequate professional pre-service and in-service training on the use of ICT confuses teachers (Selinger, 2009, p. 224). Teacher motivation is problematic, because teaching is not a first-choice profession in most of the SSA countries.

(Tedla, 2012; Mathipa, & Mukhari 2014; Minigaine 2013; Higgins & Moseley, 2011) Thus, it results in a shortage of motivated, experienced and qualified teachers (UNESCO 2012). Together with a lack of time, linked to large classes, it results in a lack of proficiency and knowledge of the potential use and roles that ICT can play in teaching and learning (Tedla, 2012).

Furthermore, demographic factors, such as a teacher's age, extreme poverty, inadequacy of teachers' salaries, welfare and morale, gender, tough working conditions, high-pressure workload and lack of teacher participation in curriculum development and evaluation, all influence daily school practice. This is often intertwined with technological illiteracy and lack of pedagogical skills.

2.4.5 Pedagogy

Most of the teachers in SSA still practice instructivist teaching methods (Tedla, 2012; Dzidonu 2010; Hennessy et al, 2010b, p. 45). Older teachers who are comfortable with the traditional way of teaching do not want to practice new and innovative methods of teaching. They are stuck on teacher-centered methods, which give them a sense of power in front of their learners. They deliver their lessons in the traditional mode of transmitting knowledge to students, by using chalk and blackboard. They believe that students learn better through teacher explanation and active listening, which is still deeply rooted in daily school practice (Tedla, 2012). 'It is difficult to change the minds of those who have been trained in this way'. Dzidonu, 2010).

Schweisfurth (2013) researched pedagogical norms typical for many sub-Saharan Africa countries. She found that lessons are dominated by lecturing, with occasional question-and-answer (98 % closed questions), copying, and individual written exercises. Orally questioning pupils is rare; boys are twice as likely to be asked a question as girls are, and more than 33% of the questions asked for choral answers. Only 3% of lessons included pair or group work. She observed very few cases of motivated teachers who tried new pedagogical approaches in her study, stating that 'teachers place the problems outside of themselves'. (p.4) Very often teachers do not use ICT, despite availability in their schools, because they are technophobic and afraid of innovations. Many other authors indicate similar experiences.

Basak and Govender (2015) refer to the fact that it is not merely the lack of confidence and experience with teaching ICT (implementation knowledge and digital skills, self-confidence); they also discovered a resistance to change in combination with a negative attitude to organisational change and outside interventions. Beyond that, teachers expressed anxiety and fear of failure while using ICT in a class of learners who already know more about these tools. Some teachers who resist ICT in teaching believe that ICT has no benefits for themselves and their learners, and thus, continue to use traditional methods (Mathipa & Mukhari, 2014; Dzidonu, 2010).

Teachers' positive perceptions of the use of ICT can provide useful insight and support its implementation (Keengwe, Onchwari, Wachira, 2008). However, implementation of ICT in schools, based on educational policy and curriculum context, is widely dependent on the major role school leadership plays (Makhanu & Kamper, 2012, Minigaine, 2013).

Furthermore, it is important to mention that in SSA there is a dearth of locally produced and contextually relevant content for teachers and learners. Altogether, this causes problems with implementing ICT-in-Education initiatives, and results in a general lack of ICT literacy.

A very demanding challenge limiting the successful implementation of ICT in SSA is often related to the fact that many schools are losing well-trained ICT teachers to the private sector because of higher salaries.

2.4.6 Higher Education

African higher education institutions face multiple challenges, such as staff shortages, under-qualified staff, and quality of offerings. Students' demand for higher education far exceeds enrolment. At most African public universities very low uptake rates for science, engineering and technology (SET) programmes, due to limited public funding, are challenging young people who want to enter tertiary education (Butcher et al, 2015).

The increase in students' mobile device ownership offers new possibilities for young people. They can partake in non-formal education, and higher education can offer learning resources and higher enrolments. Mobile devices support displaying content, creating activities, and promoting interactions with lecturers and peers. Pfeffermann (2014) points out, *'*what they [young people] may lack in material resources, they make up in an enormous thirst for learning, hence the exponential growth in online education.*'*

2.5 ICT Initiatives in SSA

Many initiatives attempt strategies based on how systemic integration of ICT can help improve the quality of teaching and learning, and expanding access to learning opportunities in SSA (UNESCO, 2012, Kleine et al, 2014). Organisations from around the world have implemented projects and often provide resources (hardware) to help 'Bridge the Digital Divide'. Many of these are uncoordinated small pilot initiatives, often in partnership with NGOs and donor agencies. They are mainly regionally bound, limited, donor-driven or commercially funded (Hennessy et al, 2010a, p.96; Farrell & Isaacs, 2007; Dzidonu, 2010).

SchoolNet was a non-governmental organisation working in partnership with private companies and other organisations such as Commonwealth of Learning. It supported a network of practitioners, policymakers, teachers and learners in African countries. The aim was to build up affordable and sustainable ICT access in schools in addition to the creation of locally-

developed, digitised education content. SchoolNet catalogued ICT in education initiatives in Africa.[9]

In response to increases in mobile phone coverage in SSA, mobile phone-based development projects have proliferated in a variety of sectors, including agriculture, health, education, emergency response, and governance (Aker & Mbiti, 2010, p. 222).

Mobile learning pilots and projects have had diverse aims and pedagogical approaches. Some success stories, for example MoMath in South Africa and since 2014 in Tanzania, and Yoza/M4Lit[10] gained much attention. M4Lit (Mobile Phones for Literacy), now called Yoza Project, encourages teenagers to read stories and write novels in South Africa. Yoza also has a classics section for public domain content to be studied by learners in South Africa. [11]

Large-scale initiatives facilitating informal learning in out-of-school environments to complement formal schooling are often initiated from or in cooperation with international brands or universities; most address literacy development. Some examples:

- MoMaths (Nokia Mobile Mathematics learning service) [12] is an innovative mLearning project funded by Nokia and the South African Government, MTN and MXit.
- Jokko Initiative[13], is a literacy and post-literacy activity, with special emphasis on empowering women through a mobile phone-based group message system in Senegal.
- Project ABC in Niger addressed adult participants, providing traditional literacy and math classes as well as basic mobile phone skills (Aker & Ksoll, 2011).
- The Somali Youth Livelihoods Project SYLP [14] was a skills development programme with the aim of reducing insecurity by putting Somali youth to work.
- Nokia Life Tools provides timely and relevant information, customized to users' location and personal preferences, on agriculture, health care, education, and entertainment. It uses commonly available SMS messages to deliver information and is low-priced. [15]
- M4Girls was launched in South Africa in 2008. Mobile devices (mainly mobile phones) were used to teach literacy, numeracy, math, and employability skills as non-formal

[9] http://www.schoolnet.org.za/knowledge-sharing/ no date, accessed 16.Dec. 2016

[10] https://m4lit.wordpress.com/category/yoza/

[11] https://m4lit.wordpress.com/about-the-project/

[12] (http://www.finland.or.tz/Public/default.aspx?contentid=314781

[13] http://www.unesco.org/uil/litbase/?menu=4&programme=181

[14] http://pdf.usaid.gov/pdf_docs/pdacy127.pdf)

[15] Example Nigeria https://www.naijatechguide.com/2010/11/nokia-ovi-life-tools-now-in-nigeria.html

Links accessed Dec. 15th, 2016

education. It provides learning opportunities for individuals, most notably girls and young women, who may not otherwise receive such instruction[16]

Innovative projects have often failed due to poor ICT infrastructure (Williams et al, 2011). Initiatives funded by technology companies may often not provide objective results, because they have commercial motives.

There is limited evidence available of sustainability of implementation from many other projects. Programmes based on Eurocentric notions regarding knowledge, language, culture, social reality and worldviews were often not sustainable in developing countries (Woolf et al, 2011). ICT initiatives in education cannot be simply transferred from one country to another with a different environment and politics. 'Constraints cannot be ignored. Rather than blindly importing technologies from the developed world, researchers need to explore education technology constraints within each country' (ibid, p.493). Many of the small-scale mobile learning projects in SSA only benefit a few people for a short while, and do not attempt to influence national policy. When the technical capabilities required to maintain equipment are unavailable, this prevents most of initiatives from achieving a larger scale. Most schools cannot afford the running cost of access to the Internet to support education and training after project funding runs out (Henessey & Onguko, 2010a; Mereku et al, 2009). According to Avgerou (2010) a reason for this is drawn from a rarely adequately defined socio-economic development theory and analysis.

2.6 Learning and ICT in a Wider Scope

Mere access to content through a mobile phone as a provision of learning opportunities is too limiting. Improvement in quality of education is a more complex issue. Effective use of mobile technology for learning is less about tools and more about digital skills. Digital competence, or digital literacy, stands as an important issue and often as a challenge for implementation of ICT in SSA.

Definitions of the skills people require in the digital era have evolved over time. Gallardo-Echenique et al. (2015) provide an overview of terms referring to digital competence: media-literacy, new literacies, multimodality, computer literacy, digital literacy, media education, information literacy, multi-literacies, ICT literacy, e-literacy, e-Competence, e-Skills, technology literacy, digital competence, digital media literacies, media and information literacy and 21st-century skills. The major terms in use, namely digital competence and digital literacy, are explained below.

[16] http://www.ngopulse.org/newsflash/m4girls-project-launched-south-africa

2.6.1 Digital Competence

In 2006, the European Council recognised digital competence as one of eight key competences of European citizens and one of the four foundational skills for learning, together with language, literacy and numeracy (EU 2006). Digital competence includes the ability to access, manage and evaluate digital resources.

Gallardo-Echenique et al. (2015) provide a comprehensive and detailed definition of digital competence:

- Operational practices (technological) are competences to solve common technical problems; this includes conceptual understandings of symbols, spoken and written language, images, videos, sounds, screen design, etc.
- Cultural dimension (ethical): practices in specific social and cultural contexts, respecting net-policies.
- The critical dimension (cognitive) addresses critical literacy, evaluating information, interpreting graphs, classifying and organising structured data, etc.

Calvani et al. (2010) refer to three interrelated dimensions of literacy: technological (technical-procedural), ethical (emotional-social) and cognitive skills. The interrelation of these three competences is outlined in Figure 2.3.

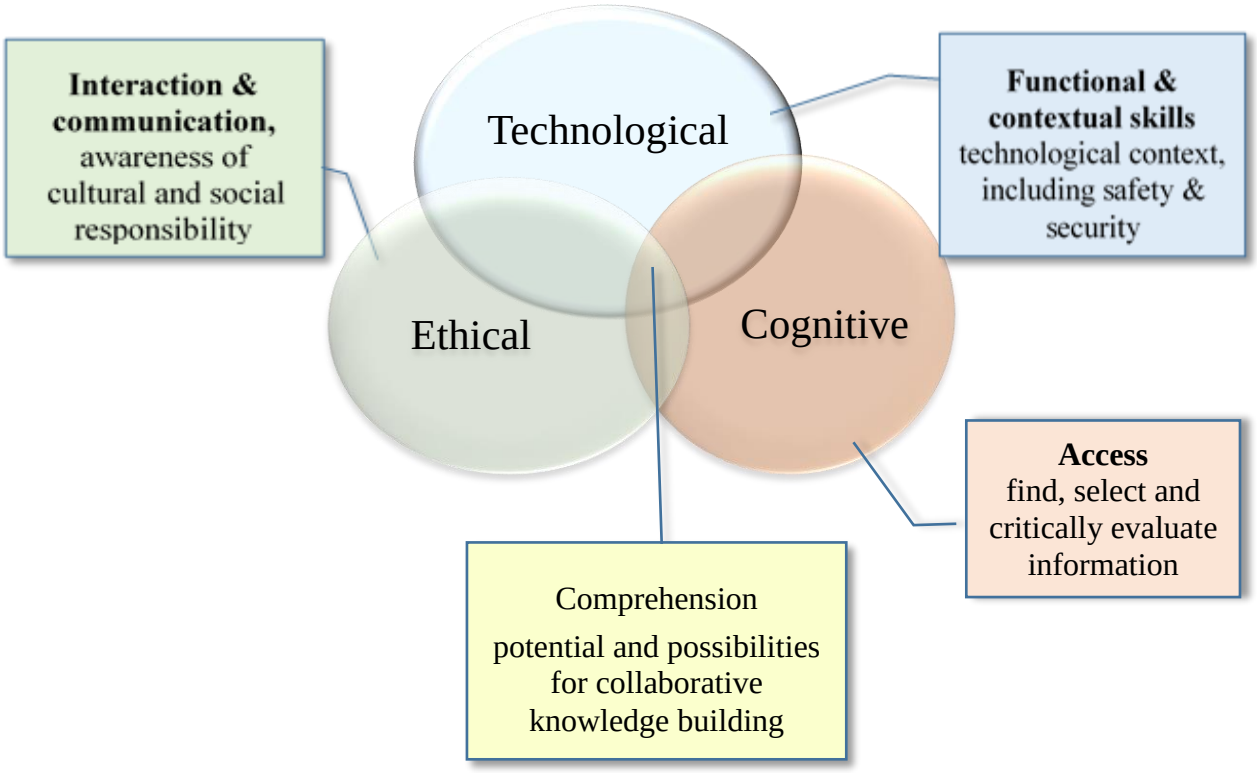


Figure 2.3 Digital dimensions and competence (adapted from the Digital Competence Framework, developed from Calvani, Fini & Ranieri 2010, p.163, and ELINET, 2016)

Digital competence is a set of knowledge, skills and attitudes. It includes abilities, strategies, values and awareness, required when using ICT and digital media to perform tasks; solve

problems; communicate; manage information; collaborate; create and share content; and build knowledge effectively, efficiently, appropriately, critically, creatively, autonomously, flexibly, ethically, reflectively for work, leisure, participation, learning, socializing, consuming, and empowerment (Gallardo-Echenique et al, 2015, p.10)

.Nowadays it is not sufficient to simply participate in digital media practice; the ability to responsively transform actively and creatively as a means of social control is relevant. (ELINET 2016, p.2)

2.6.2 Digital Literacy

Digital Literacy is part of everyday literacy, and is complex and sociocultural-sensitive. In order to clarify some issues the European Literacy Policy Network (ELINET)[17] developed a position paper in 2016, stating that diverse literacies are necessary to communicate and collaborate with others and to find and make sense of available information. They point out that literacy now includes the use of a range of meaning-making resources, e.g. manipulation of multiple modalities in diverse digital media (including social media, e.g. Facebook, Blogs, Wikis, etc.).

A set of interrelated digital skills is presented in Figure 2.4.

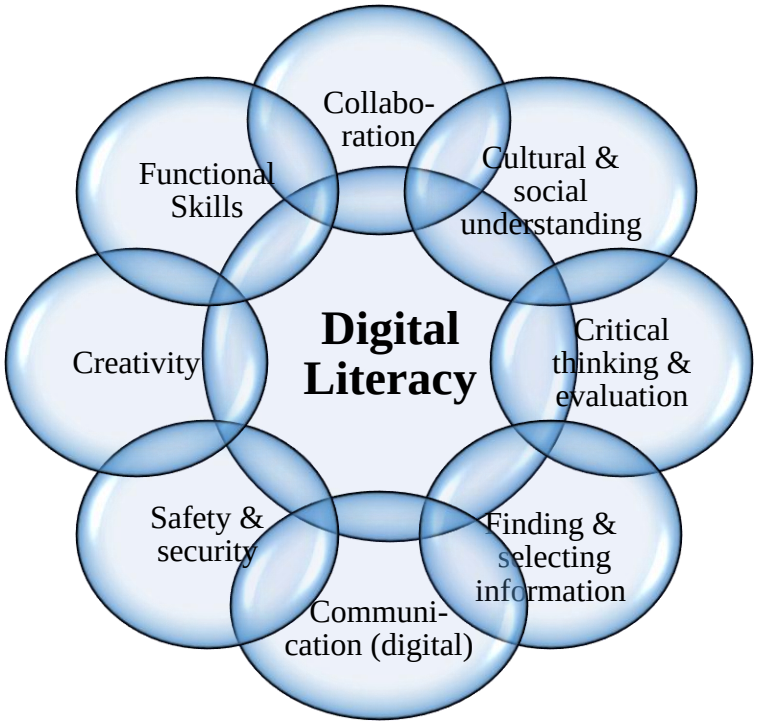


Figure 2.4 Contents of Digital Literacy (adapted from Hague & Payton, 2010, p.19)

Toner (2011) indicates that digital literacy goes beyond functional skills by involving a set of digital behaviours, practices and identities; core skills are critical thinking, creativity, problem solving, global collaboration and communication.

[17] http://www.eli-net.eu/

Calvani et al. (2010) argue that digital literacy capacity building would be a cost effective and equitable way to support the whole spectrum of development in SSA, for example health, education, safety, employment etc. Though the lack to technology access and of profound teacher training are recognised in SSA, the dimension of risks and safety aspects is sparsely considered. For lecturers, it is becoming increasingly important to be digitally literate (Zhang, Tousignant, & Xu, 2012). Specific educational interventions should encourage the development of critically, ethically and socially aware personalities (Toner, 2011).

Challenges in achieving these skills are inequitable access to technology, lack of teacher training, and online risks for physical and mental health (unintentional access to personal data, privacy issues, and exposure to inappropriate or sexually explicit material, cyber bullying).

In summary: Digital literacy or digital competence is a measure of an individual's ability to use digital technology, communication tools, and networks to access, manage and integrate digital resources, including using digital technologies safely and effectively.

Traxler points out that the interrelationships between mobile technologies, digital literacy and advancements of learning are leading to wider issues of digital inclusion and digital divides. (Traxler, 2011)

2.7 Learning and Pedagogical Underpinning

2.7.1 Intentions for Learning

It is a common assumption that people naturally want to learn. Individuals from different social contexts and backgrounds engage in learning differently. Learning occurs differently in different age groups, social contexts, genders, cultures, in developed and emerging countries and in children and adults (Wang & King, 2008; Guy, 2009).

Learning is much more complex than just making assumptions on information dissemination. It is embedded throughout our lifetimes, creating ideas and developing skills, sometimes as an explicit objective, or as an unintended consequence. Changes in learning are both a reflection, and a consequence, of how we now want to live (Hase & Kenyon, 2001; Sharples et al, 2005). Thus, how people live influences how people learn. According to Ryan and Deci (2000), motivation for learning can be of two types, intrinsic and extrinsic. Intrinsic motivation refers to internal thought processes such as curiosity and achievement. When a person has clear goals and means to meet them, s/he is more motivated. Extrinsic motivation refers to external rewards such as bonuses, promotions, and appreciation of one's work.

Vygotsky (1978) sees learning from a socio-cultural perspective: situated, facilitated and developed through social interactions and conversations between people. Students learn most effectively by engaging in carefully selected, collaborative problem-solving activities.

2.7.2 Formal, Informal and Non-formal Learning

Learning happens both formally and informally, taking place in everyday locations. The 'body of knowledge' today is rapidly changing.

Formal learning is traditionally characterised by two dimensions: time and space, and is.highly institutionalised, hierarchically organised and often compulsory. Learning places are fixed; learning occurs within classroom settings school buildings, it is structured in temporal slots (timetables, semester). Governments or educational providers determine goals externally, as well as the locations and methods of formal education. The teacher/lecturer decides what the learner needs to know, and how the knowledge and skills should be taught (Livingstone, 1999; Schugurensky, 2000, Kearny, Schuck, Burden, Aubusson, 2012, Latchem, 2014).

Informal learning is characterised by voluntary as opposed to mandatory participation (Livingstone (1999). Informal learning includes all kinds of learning that occur outside a curriculum and a school setting. Schugurensky (2000) identifies three forms of informal learning:

- *Self-directed* learning is intentional and conscious; the individual has a purpose for learning and is aware of having learned something.
- *Incidental* learning occurs without a previous intention of learning; it is spontaneous and unstructured, as a by-product of some other activity. The person becomes aware thereafter that some learning has taken place (unintentional, but conscious).
- *Socialisation* (tacit learning) defines the internalisation of learning regarding values, attitudes, behaviours, skills, etc.; it occurs during everyday life.

Adapted from Schugurensky, 2000

Hoffman (2005) indicated the following characteristics of informal learning:

- just in time;
- personal: settings, learning choices, content, goals, tools;
- contextual: in context when information is needed;
- individualised: to meet specific needs, based on prior knowledge;
- chunked learning, which is completed in (very) limited time;
- limited in scope, in contrast to formal training sessions.

He further makes distinctions about:

- *Accidental* learning - unorganised or occurring in unexpected contexts;
- *Intentional* learning - based on self-motivation; learning strategies are individually chosen and pursued at their own space;
- *Social* learning covers all learning activities taking place in a social context - collaboration and learning from others.

Adapted from Hoffman, 2005

Informal learning is mainly embedded when mobile technologies are involved.

Non-formal learning refers to planned learning activities of an individual in out-of-school settings or non-formal institutions. Non-formal learning is intentional from the learner's point of view; outcomes may be validated and lead to certification (EU 2008).

Social learning can include all formal, non-formal, informal or accidental learning experiences. *Seamless learning* is defined as uninterrupted learning across different environments, including formal and informal settings; the learner can use various kinds of devices. Seamless learning is streamlined by cloud computing and cloud storage, which improve education by providing students with continuous and up-to-date learning experiences to access content (Wong et al, 2012).

2.7.3 Learning Theories

The National Research Council defined effective learning, closely related to a social-constructivist approach, as an active process of building knowledge and skills (Bransford et al, 2000). Effective learning is

- *learner centred:* Building on the skills and knowledge of students, enabling them to reason from their own experience (related to constructivist theory); (p.134)
- *knowledge centred:* The curriculum is built from sound foundation of validated knowledge, taught efficiently and with inventive use of concepts and methods (mainly assigned to cognitivism); (p.136)
- *assessment centred:* Assessment is matched to the ability of the learners, offering diagnosis and formative guidance that builds on success (mainly related to behaviourism); (p.140)
- *community centred:* Successful learners form a mutually promotive community, sharing knowledge (related to constructivism and connectivism): (p.144)

Adapted from Bransford et al, 2000

Learning theories facilitate teaching and learning. Education implies adapting learning to the changing world: what and how it is taught needs to change as well. Different learning theories provide a basis for understanding how students learn and how learning is defined.

Learning theories are divided into several paradigms, representing different perspectives on the learning process**.** Basic types of learning theories are behaviourism, cognitivism, constructivism; learning is a process of connecting information sources and instructional theories (Guy, 2009). Each of these theories emerged from a particular the time, situation and the technology used at that time.

This range of learning theories emerged with the shift in education away from a focus on teaching in the classroom to an increased focus on learning.

Knowledge Acquisition

A brief typology of basic learning theories, methods and knowledge acquisition, adapted from Palaiologos (2011), Hase & Kenyon (2001) and Blaschke (2012), is presented in Table 2.1.

Instruction type, theory	*Learner*	*Learning method*	*Knowledge acquisition*
Pedagogy, instructivism	Children	Teacher-driven	Receiving knowledge
Andragogy, constructivism; connectivism (online)	Adults	Learner-driven; Self-Directed Learning (SDL)	Interactive knowledge, Exploring knowledge
Heutagogy	Children, Adults	Self-determined	Knowing how to learn

Table 2.1 Typology of learning theories (adapted from Palaiologos, 2011; Hase & Kenyon, 2001, and Blaschke, 2012)

Pedagogy

The term pedagogy is grounded in the Greek language: leading (*agogy*) the child (*pedi*). Pedagogy means the science of teaching; it is content-focused and teacher-driven, based on an instructivist learning theory (instructional learning). The teacher leads the learner to a conclusion determined by the teacher; the learner is informed by the teacher's knowledge and beliefs (Hase & Kenyon, 2001; Palaiologos, 2011; Laudrillard, 2009). The focus is on the organisation of instructions, closely related to the concept of behaviourism (stimulus-response-mechanism); this means receiving knowledge, usually for young learners in a formal setting (school).

Andragogy, self-directed learning (SDL)

Andragogy is a learner-centric or collaborative approach, based on constructivist learning theory. Andragogy is derived from the Greek word *andras (*man) and *agogy,* which means *man-leading.* In the 1980s, constructivism evolved as an extension of cognitivism; learning happens when a learner is able to construct new knowledge with the help of ICT. The learner constructs new knowledge through a process of analysing new information and comparing it to previous knowledge (Hase & Kenyon, 2001; Palaiologos, 2011; de Waard et al, 2015). It emphasises the needs of individual learners and their engagement in the learning process (internally motivated). It is interactive; knowledge is co-constructed by learners and instructors. It is also task- or problem-centred and related with youth education and adult learning (Blaschke & Brindley, 2011, Palaiologos, 2011). The focus is on developing life skills and competences, which enable young people to succeed in a fast-changing world of challenges and opportunities (UNESCO, 2008). Annotation: Some authors are no longer using the term teacher within constructivist theory, calling this position learning-leader instead.

Heutagogy, self-determined learning

is an extension to andragogy. Learners are highly autonomous and self-determined. Self-determined learning focuses on the process of *learning how to learn,* not on the content, as a basis for dealing with innovation and the changing structure of communities and workplaces. (Hase & Kenyon, 2001; Ladell, 2012; Blaschke, 2012; Toner, 2011) Emphasis is placed on development of learners' capacity and capability. The more individuals mature the less they require instructional control. Hase and Kenyon (2001) draw a clear distinction between *self-directed learning* (andragogy) and *self-determined learning* theory (heutagogy).

Vavoula and .Sharples (2009) describe self-determined learners as effective learners, who are confident to manage their own learning process. Knowles et al. (2015) refine the definition: self-determined learners are able to diagnose personal learning needs, formulate learning goals, identify resources for learning, select and implement learning strategies, and evaluate learning outcomes.

Blaschke (2012) defines self-determined learning as 'supporting development of learner-generated content and learner self-directedness in information discovery and in defining the learning path.' (p. 56) The learner determines what is of interest and relevance; overall learning capabilities increase by becoming highly autonomous. She supposes that learners on the elementary level already have the potential to engage in educational experiences based on heutagogy. A heutagogical approach and mobile learning can easily be combined to extend learning beyond the classroom and in transformative ways, with participatory and collaborative interactions.

2.7.4 Learning and Technology

Sharples (et al, 2007) identify similar characteristics of mobile technology and new learning: personalised, user-/learner-centred, mobile/situated, networked/collaborative, ubiquitous, and lifelong/durable. Sharples (et al, 2005) specify the convergence between New Learning (NL) and New Technology (NT) in their theory of mobile learning, reflected in Table 2.2.

New Learning	*New Technology*
Personalised	Personal
Learner Centred	User Centred
Situated	Mobile
Collaborative	Networked
Ubiquitous	Ubiquitous
Lifelong	Durable

Table 2.2 Convergence between learning and technology (Source: Sharples, Taylor, Valuva, 2005)

Non-formal and informal learning through mobile technology are viable options for students in underserved conditions, as is the case in SSA (Latchem, 2014). Effective use of technology can contribute to informal learning by supporting sharing of knowledge locally, nationally and globally. According to Latchem (2014), 70-90% of human learning falls in the categories of informal and non-formal learning. With Web 2.0, there has been a rise in non-formal and informal learning.

Non-formal educational efforts have a long history in Africa. For example, open educational resources (OER, see 2.8.4) have been identified as having the potential to extend opportunities for learning to non-formal learners. While a number of educational apps are mapped to curriculum targets, the majority of apps are intended for informal learning (GSMA 2010).

Blended learning (both online and classroom learning), non-formal learning and lifelong learning became very important topics in research on learning and education with technological progress (Olcott, 2013).

2.7.5 Mobile Learning

Using mobile devices for educational purposes is becoming a common expectation of learners. The proliferation of mobile devices 'put[s] a computer in everyone's hands'. (Heeks, 2012) As mobile technology became affordable, effective and easy to use, learning opportunities through the Internet increased (InfoDev 2010-2011). Mobile learning (mLearning, ML) is interwoven with everyday life (Traxler & Voslo, 2014, p.20). It is a way to learn independently, anytime and anywhere, by using mobile technologies (Ally, 2009; Kukulska-Hulme & Traxler, 2005; O'Malley et al, 2003).

Berking et al. (2012) clearly point out that mobile learning is not just another method of content delivery to learners, and that it implies a paradigm shift. It can strengthen communication among peers, student access, personalisation and engagement; it makes learning easier and more effective with learning-in-context and continuity between contexts. Particular features of mobile devices offer rather different implications for new approaches to learning and teaching than former ICT tools. Steve Vosloo (2012) pointed out: 'Mobile is very much just the next chapter in the ICT for education story'. Context awareness has to be considered from different angles. In the so-called 'First World', context awareness plays a different role than in developing countries. There, context awareness is often associated with local market prices and health information (Berking, Haag, Archibald, Birtwhistle, 2012).

There exists a wide range of characteristics and definitions of mobile learning in the literature; they evolved rapidly over time with developments in technology, applications in educational settings and the learning process. Koole's model of mobile learning elaborated on enhanced collaboration, access to information and deeper contextualisation of learning, based on device, social and learner aspects (Koole, 2009). Traxler (2009a) features three elements of mobile learning: personal, contextual and situated. He describes key characteristics of mobile learning

as spontaneous, situated, lightweight, connected, private, informal, personalised, interactive, portable, bit-sized and context aware.

Main aspects of mobile learning are summarised by Sharples et al. (2005):

- It is the learner that is mobile, rather than the technology.
- Learning is interwoven with other activities as part of everyday life.
- Context is constructed by learners through interaction.
- The control and management of learning can be distributed across learners, guides teachers, resources and in the world.
- Learning can be initiated by curricula or study plans (external goals) or arise out of curiosity to form new goals (satisfy goals).
- Mobile learning can both complement and conflict with formal education.
- Mobile learning raises ethical issues of privacy and ownership (monitoring, recording, location tagging).

Adapted from Sharples et al, 2005

The value of mobile learning rests not in the devices themselves but in the ability of people to access learning wherever they want. The wide set of tools and applications allow students to experience and to interact with learning objects; thus, students are no longer tied to their desks (Grimus, 2016).

Naismith and Corlett (2006) identified five critical success factors for mobile learning (ML)

- Access to technology, either by developing ML for users' own devices, or by providing learners with devices that they can use at home and on the move.
- Ownership: Either users own the device, or they treat it as if they own it. This can bridge the gap between institutional and personal learning.
- Connectivity provides access to learning resources, link people across contexts, allow students to capture material that can be sent to a personal media space, shared or presented.
- Integration into the curriculum, the student experience, or to daily life, or a combination of all of these.
- Institutional support: Although control is put into the hands of the learner, successful projects need strong institutional support (design of relevant resources, staff training and technical support)

Valouva and Sharples (2009) proposed a three-level framework for evaluating mobile learning experience based on micro-learning usability (see 2.8.2), learning experience and integration within existing contexts.

Thus, when thinking about informal, collaborative, situated, contextual, and personalised learning, this means that mobile devices can take learning outside, away from the classroom,

the lecture, the teacher/lecturer, and the curriculum (Traxler, 2011). However, the UNESCO report states that, even when ICT is used in schools, education policies rarely address mobile learning, which reflects a significant policy vacuum (UNESCO 2012).

The following definition of mobile learning fits perfectly with the intention of this thesis:

Leveraging ubiquitous mobile technology for the adoption or augmentation of knowledge, behaviours, or skills through education, training, or performance support while the mobility of the learner may be independent of time, location, and space (Berking et al, 2012).

Mobile learning has developed largely outside of formal education contexts. A majority of mobile learning projects are designed for informal learning, offering a wide range of information about health care, agriculture and education (see 2.9., examples in SSA). Most of them focus on information dissemination.

The needs of today's education have changed. Mobile devices with Internet-access can help to address complex learning situations and carry out research, regardless of being enroled in formal education (traditional class settings) or in informal learning (outside, or not enroled in formal learning programmes) (Dzidonu, 2010, Woolf et al, 2011). Mobile learning can bridge formal and informal learning. Mobile learning is an option to overcome restrictions in spaces and time slots.

Mobile learning can potentially promote social equity by allowing marginalised groups access to decision-making. It is argued that the Arab Spring ranks among the most significant informal mobile learning phenomena in 2011 (UNESCO 2012, p. 18).

In the Global Internet Report a gap in appreciation of mobile learning in the developing and developed world is outlined. In emerging markets, more respondents (e.g. 68% in Nigeria and 66% in Kenya) agreed to 'use the mobile Internet for online learning, because it provides a great improvement to lives, while in the UK only 44% shared these sentiments'. (inet Report 2015, p. 77)

New devices themselves are a major barrier to the adoption of mobile learning, because content developed for other media does not transfer well to mobile devices, due to the size of the display as well as for technical reasons.

In summary: Mobile learning means access to educational content offered by mobile technologies without limitation of time and place, or learning that happens when the learner takes advantage of the learning opportunities with mobile devices. It offers an extensive variety of learning activities that support the learning process by means of motivation, communication, control and ownership.

Within this thesis, the term mobile learning focuses on the use of mobile devices (particularly mobile phones and eBook Readers) for enhancing access to learning material and developing

locally relevant material for use with mobile devices. In this study, mobile technology is considered an adaptable substitution for desktop technologies for learning purposes.

2.8 Mobile Pedagogy, New Learning

Mobile learning is a relatively new phenomenon, and the theoretical basis is still under development. It enables individuals to be more flexible about when they learn, and opens up a wide variety of pedagogical patterns. Fullan and Longworthy figured out how new pedagogies differ from the traditional education-model. In the traditional model pedagogical capacity is directed to develop content knowledge, which helps the learner to master required content. New pedagogies use technology to discover and master content together. Pedagogical capacity, creating and use of new knowledge in the world are interwoven, defined as Deep Learning. (Fullan & Longworthy, 2014, p.3)

It is essential to understand how learning by using mobile devices differs from traditional learning in order to define appropriate strategies for mobile learning. Educators around the world are experimenting with a wide range of applications and new teaching and learning methods in various disciplines. Usage and functionalities of mobile devices for learning are dependent on specific situations, different backgrounds, e.g. as geographically related. Traxler (2009b) and Dzidonu (2010) state that mobile technologies may deliver a qualitative change in the nature of learning, by providing new ways of education, training and learning. Mobile learning can widen the learners' scopes of action and, on a wider scope, social transformation (Seipold, 2014).

Since the needs of today's education have changed, mobile technologies create a need for rethinking pedagogical approaches. Established teaching methodologies are reaching their limits. Traditional pedagogy does not sufficiently react to the information driven world. While traditional learning is mainly related to childhood, lifelong and independent learning becomes more important. 'We are moving from being compliant citizens, being told what is good for us, to informed actors who are determining our own futures. The way we learn in the future simply has to reflect those shifts'. (Price & Price, 2014)

New learning is a collaborative process of knowledge exchange and creation. It is personalised, learner-centred, situated, collaborative, ubiquitous and lifelong (Laurillard 2007, Sharples et al, 2007). New learning is shifting away from teaching to an increased focus on learning. Mobile learning activities are based on collaboration, communication and problem solving, and support project-based learning. New learning should include learning strategies to get students excited about how far they can take their learning online. Ownership of mobile devices can be a stimulus, providing opportunities for students to become actively involved to construct their own deeper and lasting learning.

Tedla (2012) points out that mobile devices provide effective teaching-learning atmospheres. He calls for changes in teacher training and professional development, reshaping pedagogy and classroom practices from traditional learner-centred education to a constructivist approach (Keengwe & Onchwari, 2011). A very helpful overview of current perspectives and mobile learning theories is provided in the publication of Keskin and Metcalf (2011). They provide a brief summary of mobile learning theories and appropriate applications to the following theories: behaviourism, cognitivism, constructivism, situated learning, problem-based learning, context awareness learning, socio-cultural theory, collaborative learning and conversational learning.

Appropriation and application of a learning theory involves adopting available tools within cultural learning settings. Socio-cultural views of learning are taking into consideration both characteristics of mobile devices as well as social and personal learning processes.

According to Sharples (et al, 2005), a theory of learning must be based on contemporary accounts of practices that enable successful learning. Mobility allows teaching and learning to go beyond the traditional classroom; this provides a wide range of opportunities by supporting interactions with a learning environment. For example, the experience of reading electronically is rapidly becoming more conducive to learning. New textbook conversions are moving away from mere digital reproductions of printed text to visually rich interfaces and interactive eBooks, including multimedia and collaborative elements (GSMA-Kearny, 2011). User experience and search behaviour on mobile devices is different from conventional desktop search and has its own characteristics. Mobile devices with small displays offer different interaction functions. As an example, users tend to issue shorter queries than on the desktops, due to the lack of a physical keyboard (Kamvar & Baluja, 2006).

Naismith (et al, 2005) discuss theories on how mobile technologies support instruction by providing evidence that mobile devices are able to support a variety of different types of learning, based on six types of learning theories. Categories of learning theories are listed below, along with the main authors and learning approach:

- Behaviourist, drill and feedback (Founder: Skinner, Pavlov; Watson).
- Constructivist, participatory approach (Founder Piaget, Bruner, Papert, Dewey, and Montessori) learners actively construct new knowledge on previous experiences).
- Situated (Brown; learning in authentic context, problem and case-based learning, e.g. in a museum).
- Collaborative, communication and information sharing (Founder Vygotsky), computer-supported collaborative learning.
- Informal and lifelong, source of information or means of communication that assists in everyday life, supporting intentional and accidental learning. (Founder Erault).

- Learning and teaching support: coordination of learning resources for monitoring attendance or progress, reviewing, managing activities and schedules; personal organisation.

Adapted from Naismith et al 2005, with additions

Kearny (et al, 2012) presents a framework of three central features (with sub-sections) of a pedagogical perspective of mobile learning, based on a socio-cultural perspective*: authenticity* (contextualization, situatedness), *collaboration* (conversation, data sharing) and *personalisation* (agency, customization). They distinguish three groups of interaction theories: *cognitive* (student and content), *social* (peer-to-peer) and *teaching* (student-teacher).

Problem-based learning methodology was developed in response to the needs of professional practice, as a way of ensuring that learners are not only able to pass examinations but can also apply the concepts that they have learned in practice. (Sharples et al, 2014, p.23)

Most important is, that the adoption of mobile learning is related to lecturers' skills in using digital technology (digital literacy, see 2.6.2). It is interlinked with skills needed for integration into teaching (teaching self-efficacy), and belief in their ability to perform the task; perceiving self-efficacy gives the confidence the person needs to perform specific actions to meet the established objectives. Cultural, social and technical components for successful implementation of new learning styles have to be considered. This also includes topics such as prior experience, and how learners needs are explicitly addressed (Laudrillard, 2007).

Learners need to be well prepared for the complexities of today's workplace. In higher education, when students develop their own learning skills, self-directed learning becomes even more important: students can learn within communities, construct knowledge and learn from one another. Self-determined learning is engaging, relevant to students' lives and future.

2.8.1 Learner-centred Education

Research on learner-centred and self-directed learning (SDL) emerged in the 1970s (Hase, & Kenyon, 2001; Palaiologos 2011; de Waard et al, 2015). Making students ready to live and learn in a web-connected world is a necessity. When information is instantly available, teachers/lecturers are no longer the single source of knowledge. Mobile Web 2.0 is linked to the constructivist paradigm, shifting from passive consumption to active participation, based on principles of active, experiential, authentic, relevant, networked learning experiences, typically combined with the use of collaborative digital tools. (Woolf et al, 2011; Laudrillard, 2007; Palaiologos, 2011) Learners are personalising and structuring their learning processes and environments (Sharples et al, 2005). The constructivist paradigm expands to a connectivity paradigm when learning happens when learners are connected by using web-based (online) materials and social media with mobile technologies.

Learner-centred education has become an important issue on a local, national and global level. The innovative use of mobile devices for learning purposes promotes student-centred learning and enables informal and non-formal learning (Kearney et al, 2012). Educators' role is to help students to develop the capability to become autonomous and lifelong learners. Teachers are expected to update their pedagogical practices to enhance the teaching profession, and to allow for integration with informal learning. Educators need to examine what they are teaching, and the population to whom they are teaching (Hase & Kenyon 2007).

By using a mobile device, students can easily access supplementary material in order to clarify ideas introduced in a classroom. Students are gaining control of their learning. Learners are increasingly forced to take responsibility for creating their own learning pathway by choosing what they want to learn, and the most appropriate method of learning. Specific applications can positively affect students' learning and motivation, skills and attitudes. (Hase & Kenyon, 2007; Dzidonu, 2010)

Encouraging self-directed informal learning is important for development (Hague & Logan 2009). Michele Schweisfurth evaluated studies on learner-centred education in developing countries. She states: 'What is learnt, and how, is shaped by learners' needs, capacities and interests'. (Schweisfurth, 2013, p. 20) Her statement is of great importance for the present research, because perceptions and motivations of teachers and learners are a crucial issue to be observed.

2.8.2 Educational Micro-content, MicroLearning

MicroLearning is a new form of technology-enhanced learning. It is learner-driven and deals with relatively small learning units (micro-content consists of small chunks of information) and short-term learning activities. MicroLearning facilitates self-directed lifelong learning, because short activities can be flexibly arranged, individually aggregated and easily integrated into everyday activities. MicroLearning facilitates new ways of bridging informal and (non-) formal learning in a mediated world. Educational micro-content can be considered as learning objects, perfectly suited to mobile devices. (Souza & Amaral, 2014; Buchem & Hamelmann, 2010)

According to Buchem and Hamelmann (2010), active participation of learners in the process of co-creation and distribution of micro-content is an important aspect of microLearning. It offers new opportunities for designing and organising learning, e.g. learning in small steps with small, loosely coupled units of digital information. Micro-chunks of information are focusing on a single idea or topic. Micro-content may consist of text, video, audio, images, graphs, photos, etc.; these resources can be merged into a single micro-content unit. They can be individually produced, aggregated, updated and reused. 'By learning and repeating step by step the content learned will be secured in the long term memory, thus, learning is easy, unobtrusive and sustained.' (InTouch-ICT 2013, p. 9)

Design of MicroLearning focuses on adequate pedagogical strategies and tools (Souza & Amral 2014). Attention should be paid to context and background knowledge of learners. Micro-content units should have a clear focus (title, particular topic, keywords) and be self-contained, i.e. the information should to be comprehensible without the need to search for additional, external information. Restrictions might be related to aspects of usability (screen size, keyboard) and mobile connection. Development of micro-learning units was an important issue in the activity-sections of this research (see sections 4.5 and 4.6).

2.8.3 STEM (Science, Technology, Engineering, Mathematics) Education

The term STEM education refers to teaching and learning in the fields of science, technology, engineering and mathematics, and includes educational activities across all grade levels in both formal and informal settings (Gonzalez & Kuenzi, 2012). According to Fortus (et al, 2004), STEM education can enhance students' creativity and imagination; students learn to reflect on the process they take in problem solving and retain the knowledge and skills they gain (McKinsey Report 2013, p. 54).

STEM education focuses on real-world authentic problems, which matches perfectly with aspects of mobile learning. Thus, teachers should allow students to use mobile technology to interact with each other, to access information, and to interact with experts in the field (Ally & Samaka, 2013).

Integrative STEM education means general education with the intent to prepare individuals for a science- and technology-rich society (Sanders 2012; PDE 2014). Integrated STEM education is viewed as an option for making learning more connected and relevant for students 'in the natural intersections of learning within the continuum of content areas and educational environments'. (Wells & Ernst, 2012)

The WorldBank Report (2014) finds that addressing the demand for research skills in education is an important strategy for Africa's socioeconomic transformation and poverty reduction. African government ministers agreed in March 2014 on a 'Joint Call for Action to adopt a strategy that uses investments in science and technology to accelerate Africa toward a developed knowledge-based society within one generation'. Policymakers extended the educational policies by including 'widespread STEM literacy, as well as specific STEM expertise, to be 'critical human capital competencies for a 21st century economy'. (Gonzalez & Kuenzi, 2012, p.1)

2.8.4 Open Educational Resources, Massive Open Online Courses

Open Educational Resources (OER) and Massive Open Online Courses (MOOCs) provide resources and opportunities for everyone to learn by allowing access from anywhere and at any time, to suit each learner's needs. They are available in different formats and can be accessed with various devices by using different systems and tools. They allow flexibility in the use,

reuse and adaptation of learning materials for local contexts and learning environments. Thus, OER can raise the quality of education at all levels. OER have also been identified as having the potential to extend opportunities for learning to non-formal learners who have personal interest in a subject or topic, and are interested in professional development or studies related to work.

There exists a variety of definitions of OER; for example, Kawachi (2014) defines OER 'as a technology-enabled self-contained unit of self-assessable teaching with an explicit measurable learning objective, [….] has an open licence attached […], and is generally free-of-cost to use'. […]'should be designed to be easily adaptable by re-users, should be easy to download for use offline, is portable, and is transmissible across platforms.' (p. 12)

Atkins (et al, 2007) refer to OER as any educationally useful material, as modules, student guides, teaching notes, research articles, videos, assessment tools and interactive materials (simulations, databases, software, apps), that allow adapting and reuse.

Openness promotes cross-cultural understanding and diversity; knowledge and high-quality material can be beneficially shared when they fit with the curriculum, as a form of supplemental material to meet the demand for qualifications. (Grimus, 2016) However, using OER successfully depends on the infrastructure, costs and access to mobile networks, and on the skills of the population. Ally and Samaka (2013) clearly point out that classroom face-to-face courses should not be copied and provided as OER.

A MOOC is a kind of educational delivery that is massive (no limit on enrolment), open (optional admission requirements, usually no tuition fee) and online, with a defined curriculum, leading to an award of a completion certificate. (EDUCAUSE 2013) MOOCs demonstrate that it is possible to design methods of learning that improve with scale (Khalil et al, 2016). MOOCs can provide a way to fill gaps in local expertise in SSA by providing large-scale access to high-quality courses on required skills. (Boga & McGreal, 2014) They can be particularly successful if instructors are able to adapt content to the use on available devices.

The pedagogy of a MOOC is based on learning through conversation and social networking (network effect), and building on personalisation. Learners engage in productive discussions, share experience and build on their previous knowledge. (Sharples et al, 2014) Interactions are increased as compared to other delivery methods, with people around the world exchanging ideas and sharing perspectives. MOOCs are also advantageous for testing new methods of teaching, learning and assessment (Ebner et al, 2014a, Khalil & Ebner, 2015).

Boga and McGreal (2014) emphasise that instructional design for mobile phones has a similar pedagogical underpinning as the instructional design of MOOCs. It allows students to receive high-quality instruction on devices they are familiar with, by taking part in learning activities that are similar to those offered in the developed world. Use of mobile phones in education is not bound to traditional pedagogy; many MOOCs are based on constructivist principles.

‘Combining MOOCs with mobile phones could be a very powerful way to educate large numbers of people in the developing world.’ (p. 2)

2.9 Mobile Learning in SSA - Context

Countries in sub-Saharan Africa are still struggling with student enrolments to reach the Education for All goals (EFA 2000, EFA global Monitoring Report, 2013). Mobile learning offers enormous chances, especially for the youth in SSA, however likely less for the current, largely illiterate elderly population.

2.9.1 Advantages

Mobile technology is seen in SSA as the chance to compensate for challenges such as the lack of books, distance to schools, girls’ education and high dropout rates, and can enable innovation. (Traxler, 2011; Mathipa & Mukhari, 2014; Tedla, 2012) Mobile learning in Africa is a reaction to different challenges and different limitations. (Traxler, 2009a)

In recent years, numerous publications have outlined benefits of mobile learning and of integration of digital devices into education, indicating that mobile learning can overcome weaknesses and gaps in formal education in SSA. While secondary school attendance and completion in SSA is still strongly influenced by poverty, location and gender, mobile solutions can help to compensate for the lack of infrastructure. According to Winters (2013), mobile learning is viewed as having potentially transformative effects on the educational systems and on the learning opportunities provided to benefit marginalised learners in SSA.

Ally (2009) refers to the potential of mobile learning to reach people who live in remote locations where there are no schools, teachers, or libraries. Millions of people who are excluded from formal learning due to poverty, disease and conflict are now in the position to access information and learning material with their mobile devices (see 2.5 ICT, Initiatives in SSA).

Digital and mobile technologies can complement existing teaching and learning methods, and help teachers in lesson preparation and delivery. (Nyambane & Nzuki, 2014) Pfeffermann (2015) refers to mobile learning as the only practical way to sidestep huge physical and computing infrastructure deficits in SSA. He points out that mLearning can help in achieving target 7 of the Post 2015 Development Agenda, ‘to close the teachers’ gap by recruiting adequate numbers of teachers who are well-trained, meet national standards and can effectively deliver relevant content, with emphasis on gender balance’. (Post-2015 UN Development Agenda 2014, Target 7, p. 8)

Traxler states that the increase of mobile phone-ownership can support learning as a feasible option to deliver learning in Africa (Traxler, n.d.). Because the majority in SSA are currently mobile subscribers, distribution channels are already in place. Students who previously had few textbooks can now learn with the educational content available on the Internet, and teachers have access to more material and better training. (McKinsey Report 2013)

Mobile learning in Africa varies over different regions. Since inequalities are prevalent in SSA schools, there is no single model or *one size fits all approach* to supporting learning with mobile devices. The available technology has to be used in the context and social environment of the particular state.

2.9.2 Challenges

The advantages of mobile learning in education in SSA are accompanied with challenges in implementation. Due to the level of awareness of technology, the availability of infrastructure, the expertise in technology and the willingness to implement and use the technology, the adoption of mobile learning is not the same in all countries in SSA. (Osang et al, 2013)

Only few teachers are comfortable with mobile technologies. For teachers with traditional thoughts and beliefs about learning and school, changes in education will have a long way to go to become reality. The majority of teachers in SSA will need support to utilise mobile technologies in order to initiate a significant change from traditional education practice to new pedagogy. (Woolf et al, 2011) Furthermore, low bandwidth restricts the use of resource-rich materials such as video-clips, audio and video streaming, and downloading large files.

Increasing student enrolment numbers in tertiary education in SSA cannot be matched with public funding. (Mohamedbhai, 2011) Beyond that, additional enrolment without an equivalent increase in infrastructure and other resources does not achieve desired educational outcomes. mLearning strategies can potentially improve institutional efficiencies and enable national education system transformation, which is a chance to improve the educational situation in SSA countries. (UNESCO 2012, p. 7)

Non-formal learning is a perfect complementary solution for those who are excluded or not enroled in formal education. Motivated students can access OER and MOOCs (see 2.9.3), if they are familiar with this mode of self-directed learning. (Butcher et al, 2015) For this reason, it is important for Senior High School students to be well prepared to find, value and succeed with learning material available for mobile devices on their own after finishing school, or if they cannot afford study fees.

It is the intention of this thesis to identify strategies that address learners' and teachers' attempts and demands to utilise mobile technologies for learning in a Ghanaian SHS.

2.9.3 Mobile Phones, Potential for Learning in SSA

Mobile has become largely synonymous with mobile phones as tools to support development, and focus on affecting the education system. (Unwin, 2015; Clough et al, 2009) In Africa, mobile phones are more ubiquitous than previous ICT solutions, and most people already know how to use them. The enormous spread of mobile phones and mobile networks in SSA makes mobile phones particularly well suited for improving access to education. They can enable an

improvement in the quality of education by opening up new ways for informal, personalised and situated learning, and opportunities for connecting learning inside and outside of a school. Mobile phones serve as a tool for a variety of individual, personalised uses, very often in combination with social media, and are influencing daily life. They are currently also powerful computing devices, offering a variety of learning opportunities, formats for creation, and spaces for expression that were not previously available. (ELINET 2016)

According to Unwin (2015), as a learning device, the mobile phone has several key advantages. It offers a large-scale impact due to portability, affordability, accessibility and versatile features. He further indicates that mobile phones are always available to support both spontaneous as well as planned learning activities (intentional and unintentional informal learning). In summarising features for using mobile phones for learning purposes, he notes:

- they are more affordable and readily available to a wider range of people than fixed computers;
- they can be used wherever there is wireless technology: mobile cellular networks or wireless local area networks (WLAN) linked to the Internet (Wi-Fi);
- they are much more personally adaptable than many other digital devices;
- they are small and generally quite easy to use (functionality).

Adapted from Unwin 2015, p. 3

Mobile phones for learning are the chance in SSA for dealing with the challenges of poor infrastructure (unstable mains electricity and poor broadband connectivity), lack of PC availability, and technical and human capacity. Unwin (2015) states that other technology options that might deliver learning in Africa are practically non-existent. Thus, mobile phones imply promising opportunities to cope with the systemic crisis in education and to address a wide range of inequality in SSA: (UNESCO 2012, p. 6)

Considerations for using mobile phones as learning tools include features such as limited or no dependence on permanent electricity supply, easy maintenance and easy-to-use audio and text interfaces: (Masters 2005, Stone et al, 2003)

Ownership does not, however, have a direct relationship to proficiency. Students are not as adept in using mobile technology to the extent that the devices' popularity suggests. Students and teachers must learn to create, navigate and interpret texts in diverse modes on their devices, as static and moving images and icons, spoken and written language, screen layout etc. Beyond that, mobile learning interventions are affecting speakers of a national language differentially, because digital material in local languages in SSA is scarce.

2.9.4 OER and MOOCs, Optional Benefits for SSA

In SSA, the specific challenges in access to teaching and learning material could be compensated by the huge pool of OER. The flexibility and unlimited possibilities of OER imply their potential to be an important part of the educational resources available in developing countries (Kozinska et al., 2010). OER could play an important role in teacher education in SSA, as a powerful means of reducing costs while improving the quality of education (Jobe, 2014). OER can be used to deliver training more cost-effectively, and to help educators save time on resource development by providing high quality material through open access, and thus create knowledge dissemination (Tarus et al, 2015).

MOOCs and OER could further widen access of disadvantaged students by enabling access to high-quality knowledge. OER are best suited for SSA, since they are provided with relatively low or no tuition fees, can be modified, mixed, localized or translated. Moreover, they reduce the need for costly large lecture rooms and eliminate student accommodation and transportation costs (Oyo & Kalema, 2014**).** If OER are applied according to the needs of the population in SSA, OER could make education in SSA more relevant to local developments and improve appreciation of Africa by the world (Mulder, 2008).

Most learners in SSA do not have access to desktop computers, but do have mobile phones. Because many OER and MOOCs are designed to be used on mobile devices, promoting access to instructional videos and interactive exercises, they have a major impact (Jordan, 2014). Smartphones in combination with non-formal learning initiatives (OER, MOOCs) can provide the tools and opportunities necessary to improve personal professional development.

At the time of writing, institutions from Western English-speaking countries produce most OER and MOOCs. There is a wide range of material from accredited educational institutions and experts. Some examples of well-known institutions offering OER and MOOCS are mentioned below.

- The Hewlett Foundation started in 2002 to provide 'universal access to and use of high-quality academic content on a global scale in order to increase human capital' (Open Content Initiative, 2006).[18]
- The Open Learning Initiative (OLI) of Carnegie Mellon University provides openly available and free online courses and course materials with instruction for an entire course in an online format[19].
- The Massachusetts Institute of Technology (MIT) started MIT Open Courseware (OCW) in 2002, providing free access to MIT course materials. [20].

[18] http://www.oecd.org/edu/ceri/37648209.pdf

[19] http://www.cmu.edu/

[20] http://ocw.mit.edu/courses/

- Athabasca University Press is publishing books with open access, which is contributing to bridging the learning divide and making education available for all[21].
- The Open Content Alliance offers a permanent archive of multilingual digitized text and multimedia material, which caters to different cultures and learning styles[22].
- Khan Academy provides free excellent education for students, teachers, principals or adult learners, by offering a series of YouTube videos on mathematics, physics, science and technology subjects (some translated into Spanish, Portuguese, French, Turkish and Hindi[23].
- Udacity and Coursera (one of the largest and best-known MOOCs providers) are for-profit companies, also offering free-of-charge materials[24].
- Coursera has collaborated with the World Bank and the Tanzanian government to provide MOOCs to African students in an ICT education initiative. (Boga &Mc Greal, 2014, Trucano, 2013).
- edX offers courses for free; many OER can be used, reused and modified by anyone[25].

The transformative potential of OER includes the benefits of sharing and collaborating among institutions and countries. Collaborative OER development supports capacity building in the developing world by bridging the digital divide, fostering the exchange of global knowledge, and encouraging the preservation and dissemination of indigenous knowledge (Ng'ambi, 2013). Starke-Meyerring (2010) articulated that globally networked learning environments (GNLEs) should include collaboratively developed curricula, pedagogies, and learning spaces.

Oyo and Kalema (2014) raise the need for governments in Africa to commit to MOOCs with curriculum design, accreditation, instructor training, electronic content development and delivery platforms, and provision of modern access hubs. The value of networked development increases with the number of people participating**.**

OER strategies and MOOCs in SSA focus mainly on higher education and non-formal learning. MOOCs present an affordable post-secondary education delivery method for the majority of poor students in SSA. Oyo and Kalema (2014, p. 2) state: '…MOOCs could eliminate Africa's nightmare of large school dropouts after secondary school education [….] Providing a design of MOOCs in the context of Africa's situations, such as low internet bandwidth, weak professional competencies, and lack of political support, is the first step in ensuring a future of open Higher Education access in Africa.' (p. 2)

[21] http://www.aupress.ca/index.php/about/

[22] http://www.opencontentalliance.org/about/

[23] https://www.khanacademy.org

[24] https://www.udacity.com/, https://www.coursera.org/

[25] https://www.edx.org/

Mulder (2008) points out that OER projects initiated in SSA are network-driven and use a collaborative model of content creation. Since there is limited material produced by Africans on the Internet, lecturers and scientists could be encouraged to create OERs. Adapting OERs to local needs can foster a culture of authoring and publishing, and can strengthen networks among Africans. It can also increase the quality of resources through collaboration and peer scrutiny, and spread locally developed educational material that meets local needs, as well as improving transparency (ibid). In the long run, this could evolve into competition between SSA countries and also establish a culture of sharing local educational resources, which could lead to effective modernization of educational context. Quality assurance of OER material is highly important, however.

Making information freely available to the public can also improve democracy and stability. Furthermore, OER can promote movement in democratising education by gender inclusion, in order to increase female recruitment in teaching.

Examples of initiatives in SSA

OER Africa[26] and Teacher Education for Sub-Saharan Africa (TESSA) have been supporting the creation and use of OER in Africa since 2005. Teacher training institutions in eleven African countries are collaborating with the Open University UK to improve the quality of teacher education. Modular materials have been produced in partnership with local African educational experts.

- TESSA disseminates high-quality OER, which have been adapted and translated into English, French, Arabic and Kiswahili. The material is localised to suit the unique cultural and linguistic contexts in different African countries.[27.] More than 300,000 teacher-students and in-service teachers have participated. (Harley & Barasa, 2012)
- OER Africa is active in several countries across SSA. Through partnerships with various universities in Africa and elsewhere, OER Africa helps facilitate the sharing of resources between universities and schools[28].
- Mindset [29] offers free learning content aligned with and relevant to existing school curricula; it is developed in accordance with South Africa's Curriculum Assessment Policy Statement (CAPS).
- infoDev provides a quick guide to OER.[30.]

[26] http://www.oerafrica.org/find-oer/teacher-education-oer-repositories

[27] http://www.tessafrica.net/

[28] http://www.oerafrica.org/

[29] Content is available at learn.mindset.co.za and www.youtube.com/mindsetlearn

[30] http://www.infodev.org/articles/quick-guide-open-educational-resources.

- WikiEducator is a community resource supported by the Commonwealth of Learning for the development of free educational content.[31.]
- The African Digital Library (ADL) is a collection of electronic books (eBooks) that can be accessed and used free-of-charge by any person living on the African continent. Individuals can access the library from any PC that is connected to the Internet in Africa[32].
- A sample of OER on a wide range of subjects, developed for African countries, is free for download from Wiki Educator. FLOSS4Edu OER Digital Content.[33]
- OER Commons is a teaching and learning network of shared educational materials.[34]
- Open Learning Tank (OLT) is a platform that supports and builds knowledge around the use and reuse of OER to democratize access to quality academic resources in sub-Saharan Africa.[35]

2.9.4.1.. OER and MOOCs, Obstacles for Adoption in SSA

Access to technology is the most prohibitive factor in SSA, particularly in rural areas. Although OER can be a powerful option for disadvantaged groups, it might also increase the knowledge gap, because resources to access quality OER may be only affordable for Africa's elite. (Jobe, 2015; Ngimwa & Wilson, 2012) Jobe points out those OERs need to be related to socio-cultural and economic issues. He further refers to negative attitudes towards OER, based on lack of awareness, unwillingness to find time to participate, technology-related costs, resulting in perception of OER as a foreign initiative, and lack of support with regard to institutional and national policies.

Educational offerings in English are predominant. Additionally, although free to access material is an advantage, it must be considered that most OER are currently created in the developed world, and may be less relevant for the educational needs of SSA. Aside from limited competence in English, the colloquialisms used in discussion forums or the learning culture typical for North America and Europe may be difficult to understand. Boga and McGreal (2014) indicate that this prevents many students from fully participating.

Commercial MOOC platform copyright rules can also be a barrier for local educators, limiting translation, adaptation and localisation of content and curriculum. In the long run, this could negatively affect instructors and learners' abilities to take part in these communities.

[31] https://wikieducator.org/Main_Page

[32] http://www.africandl.org.za/collection.htm.

[33] http://wikieducator.org/FLOSS4Edu_Educational_Content

[34] https://www.oercommons.org/

[35] http://ampli5yd.com/elt/ all accessed August 10th, 2016

Another challenge for learners is to find correct information when using content generated by other learners. Pérez-Mateo (et al, 2011) recommend that learners check user-generated content based on quality criteria and cultural relevance with experts in the field, to make sure that the material is accurate, in order to obtain a valid education.

Oyo and Kalema (2014) defined five baseline requirements for MOOC providers: national accredited MOOC curriculum, electronic content development, development of online and offline eLearning platforms, establishment and funding of MOOC coordination units at public higher education institutions, and establishment of MOOC access hubs at strategic locations.

2.9.5 Bring Your Own Device (BYOD) in SSA Context

Bring Your Own Device (BYOD, US terminology) approaches have the potential to reduce the cost of providing ICT in schools, and offer new opportunities for learners. Mobile phones are the most important and powerful universally accessible computing devices in the hands of Africans, other options are not affordable. (Traxler, 2012, Unwin, 2015) Large-scale progress in integrating learning with mobile devices in SSA is dependent on developing strategies that use learners' own devices. Students are familiar with their technology, and hardware costs would not be a burden for the school. BYOD strategies can encourage the responsibility of the users for their devices and thus increase acceptance of guidelines and policies. Mobile devices, when carefully integrated, can engage students in new learning activities in a classroom setting. Students can become more independent in their information seeking. According to Barkham (2012), 'it is not wise for schools that cannot afford modern ICT facilities to ignore powerful ICT gadgets in every pupil's pocket'. When used properly and integrated into teaching and learning settings, it is expected that this can bring a revolution in development and education.

This falls foul of the widespread prohibition of mobile phones in most of the African schools, as outlined by Traxler and Vosloo (2014). Due to concerns regarding inappropriate use during school hours, mobile phones are perceived as a distraction in traditional learning environments. Other reasons for restrictions are fears about theft of devices, negative sentiments about Internet misuse due to moral panic and cyber-bullying (PEW Research 2015). Altogether, this counteracts the potential of mobile phones in supporting mobile learning in SSA.

However, careful management of these new challenges, e.g. problems for students who cannot afford the devices, and for schools to manage security and privacy issues, is required. The pragmatic use of mobile devices to support the learning process is only possible when these issues are settled. In this respect, it is urgent to provide concrete strategies and guidelines for students and teachers. These strategies need to include security and safety regulations for unsupervised use and careful management of school networks.

New pedagogies for integrating learning delivered via mobile phones can be developed only when these issues have been solved. (Oyerinde 2014).

2.10 Ghana

2.10.1 Background

Ghana, officially called the Republic of Ghana, is one of the fastest-growing economies in West Africa. (Figure 2.5[36])

Figure 2.5 West Africa (retrieved from Wikimedia Commons, CC BY-SA 3.0)

Ghana obtained independence from colonial rule from the United Kingdom in 1957. [37] and is known for s*upremacy in democrac*y in Africa. (Frempong 2015) The area of the country comprises 238,540 km², and is home to approximately 28 million people, with an annual growth rate of 2.3% and a fertility rate of 4.1. (Ghana Portal[38]) Although Ghana it is one of Africa's fastest-growing economies, it faces formidable challenges: 25.2 % live below the international poverty line (1.9 US$/day), and 49 % below 3.10 US$/day. (WorldBank 2014[39]) 42% of the population still lives in informal settlements, with no access to electricity or other basic services. (McKinsey Report 2013, p. 75) Ghana has persistently high inflation rates (15.5% in November 2016 [40])

The capital and largest city is Accra, with approximately 2 million inhabitants. 38.8% of the population is under 14 years old, 3.4% are 65 or older; the literacy rate is 72%, 80% male and 65.3% female (African Statistical Yearbook 2016, p. 189-193).

[36] https://commons.wikimedia.org/wiki/File%3AWest_Africa_regions_map.png

[37] http://data.worldbank.org/country/ghana, accessed Dec 2016)

[38] http://ghana.opendataforafrica.org/

[39] http://www.worldbank.org/en/country/ghana/overview

[40] (http://www.tradingeconomics.com/ghana/indicators accessed 20/12/2016

In Ghana English is the official language of legal texts and dominates in higher education. There are around 80 spoken languages in Ghana, approximately 70% of the population can speak English.

The government of Ghana places a strong emphasis on the role of ICT in contributing to the country's economy, and considers technology literacy as 'an engine for accelerated development'. (Government of Ghana, 2003)

2.10.2 Infrastructure, Internet Use and Mobile Phones

Ghana has made some improvements in its ICT infrastructure in recent years. Mobile voice penetration and data subscriptions are quite high and improve monthly, according to McKinsey Report (2013, p 76) and Ghana Statistics (2013-2016). In 2002, only 8% of Ghanaians owned a mobile phone, in 2015 there were 35.8 million mobile cellular phone subscriptions (population of 28 million). The ICT Development Index (IDI) shows an increase of 21 ranks between 2010 and 2015 for Ghana (ITU 2016). Ghana holds the 5th position in SSA for mobile subscriptions and the 109th position of 167 worldwide[41])

Internet is extensively used in Ghana, when looking at the increase in Internet use in 2016 (Table 2.3.). Fixed broadband subscriptions (landline penetration) stand at 0.3 %; however, mobile broadband is on the rise[42].

Internet [43]	December 2016			***Increase***: from 2015 to 2016		
	Users	Penetration	Population	Users 2015		Population
Ghana	7,958,675	28,4 %	28,656,893	+14%	+976,984	+2.27 %
World	3,525 million	46.1 %	7,432 mill.	+7.5 %	+238 mill.	+1.13 %

Table 2.3 Internet users in 2016

In a study on the digital divide (USAID GBI, 2013, p.4) the '*typic*al Internet user in Ghana is described as follows: male, 32 years old, professional or government worker, lives in Accra, has a university education, uses mobile Internet access (mobile phone) and uses *principally* Facebook, email and accesses on-line news sites.' Internet access with PCs is reported with less than 10 %. A huge gap in Internet use is found with respect to education level, with 2% no formal, 2% Primary, 14 % Junior Secondary, 32% Senior Secondary, 45 % Post Secondary and 5% with Post-Grade education (ibid, p.9). The gender divide is depicted as 70% male and 30 % female Internet users (p.7). Smartphone ownership is reported to be 21% in 2015 (from 15% in 2013), gender gap in smartphone ownership is reported as 33% for men and 18% for women.

[41] http://www.itu.int/net4/ITU-D/idi/2015/ (accessed 20/9/2016)

[42] http://www.tradingeconomics.com/ghana/ Worldbank Indicators Ghana (2014)

[43] http://www.internetlivestats.com/internet-users/ghana/ (accessed 13/3/2017)

(PEW Research, 2015, 2016). English language ability is also an indicator of smartphone ownership in Ghana. Adult smartphone owners reported Internet use several times a day; it has increased by 19%, from 35% in 2014 to 54 % in 2015 (PEW Research, 2015).

2.10.3 Education

Education is the most important aspect of providing people with the basic knowledge, skills and the competencies to improve their quality of life at all levels of development (Ghana 2014, Country Opinion Survey). Basic education in Ghana encompasses six years of primary school (after two years of kindergarten) and three years of junior high school (JHS). When school fees were abolished in 2005, primary school enrolment increased drastically. Students may study in any of eleven local languages for the first three years; thereafter English is the norm. (Education System in Ghana, n.d.)

After finishing JHS, students may enter Senior High technical or vocational Schools (SHS, secondary education) for four years. SHS prepare students for university education (Polytechnics, Universities and Colleges of Education). Ghanaian SHS is equivalent to the K8-12 North American educational system. Secondary and tertiary schools require tuition fees. Consequently, the poorest quintile attends school six years on average and the richest quintile eight years. Entrance to universities is by examination (West African Senior Secondary Certificate Examinations, WASSCE), following the completion of SHS. Only students who obtain aggregate 36 or better in six subjects can enter university (ibid). Until recently, emphasis in the education system has been much more on quantity rather than on quality. This is related to the Millennium Development Goals (MDG), which focused on primary education for all.

It has to be noted that in Ghana the curriculum exams and assessments are in English, even though most students rarely speak English anywhere else but the classroom (UNESCO 2016, p.21).

Reports from national research teams show significant gender-based differences (Karsenti et al, 2012). At both the tertiary and the pre-tertiary level, male educators and learners outnumber females. At least 25% of the teachers are female, compared to approximately 40% female learners.

2.10.3.1 Ghana's ICT Policies

To expand ICT access and quality has become priority for the Ghanaian government. With the Ghana ICT4AD policy in 2003, the Government of Ghana has placed a strong emphasis on the importance and utilisation of ICT in contributing to the country's economy and poverty reduction. (Acquah, 2012) The country's medium-term development plan, captured in the Ghana Poverty Reduction Strategy Paper and the Education Strategic Plan 2003-2015, suggests the use of ICT as a means of reaching out to the poor in Ghana. (Malcalm, 2012) The ICT4AD

policy was updated in 2008 with the ICT in Education Policy (Government of Ghana, Education Reform 2007[44]).

2.10.3.2 ICT Policies in Education

The Ghanaian government has committed to a set up a comprehensive programme of rapid deployment, utilisation and exploitation of ICTs within the educational system (Dzidonu, 2010). 'The Government sees the deployment of ICTs within the educational system as a means for facilitating the transformation of the educational system to provide the requisite educational and training services and environment capable of producing the right types of skills and human resources required for developing and driving Ghana's information and knowledge-based economy and society'. (ibid, p.7) Initiatives for professional development (pre-service and in-service), standards and norms for student performance, and incorporating project-based and other collaborative approaches that integrate the use of technology into the curricula were planned. (Ghana 2008, p.15)

From September 2007, Ghana's policy has been to promote ICT as a learning and teaching tool for all subjects in the school curriculum at all levels of education: primary, secondary, vocational and technical schools. (Agyei 2013, p. 79) 'It is the government's desire that through the deployment of ICT in education, the culture and practice of traditional memory-based learning will be transformed to education that stimulates thinking and creativity necessary to meet the challenges of the 21st century'. (Mr. Alex Tettey-Enyo, cited in Ghana 2008, p.2) Farrell et al (2007) stated that local support in infrastructure must be developed and made available to schools (p. 17).

Objectives of the Policy framework on systematic ICT integration, 2007, read as follows:

- Establishment of the necessary infrastructure needed for the installation of relevant ICT within the Education Sector
- Equitable access to ICT for all students and community
- Integration of ICT into the curriculum
- Development of appropriate content for Open Distance and e-Learning
- Provision of appropriate ICT training to all teachers
- Development of institutional capacity in the use of computer-based management tools to enhance administration and management
- Ensuring effective support and maintenance of ICT infrastructure
- Institution of monitoring and evaluation policies and procedures to access the ICT in Education Program.

Adapted from Acquah, 2012

[44] http://www.unesco.org/education/edurights/media/docs/6ea1d3dfbfe6402af81e83cf6031eaed279778f8.pdf

2.10.3.3 Implementation of ICT in Education

The mere inclusion of ICT in the curriculum does not guarantee effective realisation of a government's vision. Some aspects have been implemented, mainly as ad hoc initiatives or based on small projects (see OLPC 2.10.4). Despite the postulated importance of ICT in schools to bring desired improvements into the reach and improve quality of education, many factors have been identified as challenges to its integration. It has to be noted that in Ghana, as in most developing countries, institutions were built without provision for Internet and local area network (LAN) wiring. (Asabere, 2013)

An international survey in 2009 rating ICT development in 156 countries found, that Ghana still lags behind in ICT development and ICT literacy, similar to most of the African countries. (MOE, 2009; Mereku et al, 2009) Without the relevant resources, the curriculum in Ghana was not implemented in the manner that was originally intended. Limitations of devices, pedagogical issues, safety and security concerns, training and support issues could not be effectively overcome. (Acquah, 2012; Malcalm, 2012; Buabeng-Andoh, 2012a) Later research came to the same conclusion. (Danso, 2016, Quaicoe & Pata, 2015; Sarfo et al, 2016). All studies refer to limited resources within schools as the reason for very limited use of ICT in education in Ghana.

The ICT strategy adopted by the government did not take into consideration teachers' skills, attitudes and reactions towards the new tools (Hennessy et al, 2010b, p.45). According to Buabeng-Andoh (2012a), teacher training institutions have continued to emphasise teaching *about* the technology rather than *how to use* technology in teaching. He refers to a likelihood of teachers teaching students about ICT in an abstract manner, due to inadequate facilities, rather than using ICT as a learning tool. Research from Malcalm (2012) and Sarfo (et al 2016) found that even teachers with sufficient skills in technology failed to integrate their technical know-how in pedagogy.

2.10.3.4 ICT in Secondary Education

In their study on implementation of ICT Policies in Ghana, Sarfo and Ansong-Gyimah (2011) conducted a study on access and use of ICT tools in secondary schools. The study did not reveal any findings about secondary school teachers' access and use of ICT tools and their competencies in the use of ICT tools. Malcalm (2012) refers to the lack of adequate ICT infrastructure and facilities as one of the challenges. These obstacles are exacerbated by irregular electrical power supply, which is a general problem because of the nationwide power crisis. As a result, most schools are not using ICT in education (Danso, 2016).

2.10.3.5 ICT Integration in Senior High Schools (SHS)

The Ghana Senior High School ICT-connectivity Project (2012 – 2013) was set in place by adapting the UNESO ICT Competency Framework (ICT-CFT) for Teachers for SHS in Ghana with the introduction of ICT,

- as a core subject (teaching syllabus for ICT (core) in Senior High Schools, [45] and
- as an elective subject.

Malcom and Godwyl (2012) pointed out that in Ghanaian SHS, the fundamental problem is the high price of computers and the lack of infrastructure to implement ICT. Schools have very limited ICT facilities, concerning the functionality of the computers provided and student to PC ratio. (Amenyedzi et al, 2011) Research on e-Readiness in 2009 attested that only 56.92% of the computers were functioning, as a result of poor maintenance, lack of air conditioning, unstable electric power supply and virus infection. Mereku et al (2009) and Agyei and Voogt (2011) found, that 22% of schools reported local area networks, and 17.7% had Internet access. In various regions of Ghana, the student-computer ratio varied from 50:1 to 33:1 (Mireku et al, 2009 p. 25). Similar ratios are reported from pre-service teacher training institutions (Agyei & Voogt, 2011).

2.10.4 One Laptop Per Child (OLPC) in Ghana

The most well-known portable computing initiative for developing countries globally is the One Laptop per Child (OLPC) project, initiated by Nicholas Negroponte at the MIT Lab in 2005. Laptops were originally judged as the solution for Africa's varied problems in education, including poverty alleviation and access. OLPC programmes are a 1:1 strategy, supplying every learner with his or her own device.[46]

OLPC projects in Africa have been severely criticised in development studies, because the projects focused more on providing access to technology than on training teachers and students to use technology to facilitate learning. Many researchers stated that the utopian vision of education failed to consider the complex social problems faced by learners in marginalised communities, and the historical context of technology and development. (Fox Buchele & Owusu-Aning, 2007)

The Ghanaian government developed an OLPC policy in 2007, as part of the ICT4AD Policy for primary and secondary schools, with the aim of improving quality in education. The implementation was conducted on a pilot basis, so that the scarcely available resources could be effectively deployed to a limited number of schools. The study aimed to draw a picture of

[45] http://www.ibe.unesco.org/curricula/ghana/gh_us_it_C_2010_eng.pdf

[46] http://wiki.laptop.org/go/OLPC_Ghana

estimated costs, benefits and challenges in advance of a full implementation. (Fox Buchele & Owusu-Aning, 2007; Hennessy et al, 2010b, p. 44)

The pilot, in order to evaluate possible implementation of OLPC in the fourth grade in Ghanaian education, started in 2008 with 80 learners in two classes. It was expected that the tools in the hands of pupils might have a high impact on education in general, because schoolchildren could 'teach their parents, uncles, aunts and grandparents how to use the machine, not only computer literacy, but by following constructionist learning theory up the age ladder, overall literacy and educational status would likely increase throughout Ghana.' (Fox Buchele & Owusu-Aning 2007, p. 118) The Ghanaian OLPC attempt, which was initially intended to distribute 10,000 laptops, was not implemented as planned, because the project has failed to have a positive impact on education: Although access is important, it is not sufficient (OLPC News 2010).

A final evaluation after the Ghanaian pilot project was conducted in 2013 with the goal to answer the question: 'Are laptops the best use of such an investment?' (Owusu-Ansah, 2015) Owusu-Ansah surveyed teaching quality and methodology, and stated that this project failed due to the lack of infrastructure and power supply. He further asserts that unqualified tutors hindered the attainment of policy goals. It was outlined that beneficiaries of the MX laptops did not necessarily improve learning. 'Children are excited when they receive a laptop, but they are confused about the use of machine when there is little guidance.' (p.16)

Child ownership also led to many issues in managing machines. Similar pilots have failed in Nigeria, because they are only effective if further support is provided over the longer term.

2.10.5 Summary - ICT initiatives in Education in Ghana

According to Asabere (2013), 'the National ICT policy on education was not effectively implemented as it was intended', because of a gap between rhetoric in government policy and the real situation in educational practice. (Agey, 2013; Latchem & Jung, 2010; Kozma, 2008) According to Malcalm (2012), the implementation process of ICT in education at SHS was fraught with operational and leadership challenges.

2.10.6 Ghana's Youth

Research on Internet experience among Ghanaian users was conducted with undergraduate students at the University of Education in Winneba. The study focused on youth 'because they were considered more Internet savvy and constitute a greater proportion of the Ghanaian population'. (Frempong & Vaccari, 2015, p. 398) The study reveals that the youth had the greatest Internet usage, with more male online users than female users. 32% of Internet users were between 18 and 34 years of age; 18% were older than 35 years. 'Mobile phones were the most used device to access the web all the time [.....] with smartphone leading in the category of phones used.' (p. 404) Most popular activities are the use of Google, Facebook, Yahoo, Microsoft, and Wikipedia. YouTube is also frequently used.

Osiakwan stated in his presentation during the eLearning Africa Conference in May 2012: 'The implications for literacy increase through the transition away from only voice and SMS phones towards more sophisticated smart-phones, where educational content can be accessed and learning achieved.' (Osiakwan, 2012, p. 38). He referred to the mass of online content and the potential for youth in the remotest parts of Ghana, enabled by mobile broadband and a smart-phone, to have the option to acquire the same knowledge as elsewhere in the world.

2.10.7 Conclusion - Ghana

Factors affecting education in Ghana in general are teaching quality and methodology. A relative lack of ICT resources in schools limits the integration of ICT in daily practice. The desire of the ministry of education and sports (MOE) to integrate technology into classrooms seems to currently outweigh actual organisational capacity. Computers 'are highly underutilised since the curriculum is not aligned with computer based learning activities'. (Owusu-Ansah, 2015, p.15)

Statistics outline a high level of mobile phone and mobile Internet use in Ghana. As mobile phones are accessible to communities in remote areas, they also extend the reach of mobile-enabled educational resources. (Valk et al, 2010)

The large-scale proliferation of mobile phones among the youth in Ghana can increase access to learning material in many ways. However, students in Ghana are actively using smartphones to support their learning, but current learning systems, ICT infrastructure, and teaching practice does not supply their initiatives. The research points out that mobile learning is the future of education in Ghana. However, mobile learning implementation strategies require policy makers to be informed about technology and to seek opinions from relevant stakeholders and ICT vendors. (PEW Research 2015)

2.11 Conclusion (Chapter 2)

In this chapter a literature review of ICT integration and relevant issues for integration of mobile learning in Ghana, based on the background of interrelated issues in sub-Saharan Africa is elaborated. After reviewing the background of SSA strategies and developments in ICT integration in general, and in education policies in particular, the focus is laid on learning.

Mobile learning can be characterised as a specific opportunity within education systems. However, it is less clear how this can become a powerful educational intervention in SSA.

After an extensive review of interrelated issues in SSA, education policies, learning theories in terms of utilisation of mobile devices for learning, a closer look on research relevant issues with respect to the Ghanaian situation is presented. Different aspects of learning theories with respect to mobile learning and the use of mobile phones for educational purposes are investigated.

In the following chapter, the research methodology of this study will be discussed and elaborated to provide the reader with background information on how the research was planned and conducted.

3. Research Methodology

3.1 Introduction

The purpose of research is to generate new knowledge about how and why interventions work and improvements are obtained. (van Akker, 1999) A research methodology is the use of a plan of action, design and strategy in order to achieve desired outcomes, and to create a new understanding of a research problem. A research design provides a road map for conducting a study to best meet the certain objectives. (Creswell. & Plano, 2007; Denscombe, 2014)

According to van Akker, 'development research is often initiated for complex, innovative tasks for which only very few validated principles are available to structure and support the design and development activities'. (Akker, 1999, p 7) 'Researchers should not only concentrate on the question of whether a theory yields coherent and accurate predictions, but also ask whether it works.' (p. 4)

This chapter describes the rationale for developing the research strategy in relation to the field of the specific research and provides details of how the study was conceived, designed and organised. (Figure 3.1) Research methods, timeline, location details, environment, participants involved, data collection instruments, analysis and ethical considerations are outlined within the context of the introduction of mobile learning in a Ghanaian Senior Secondary School.

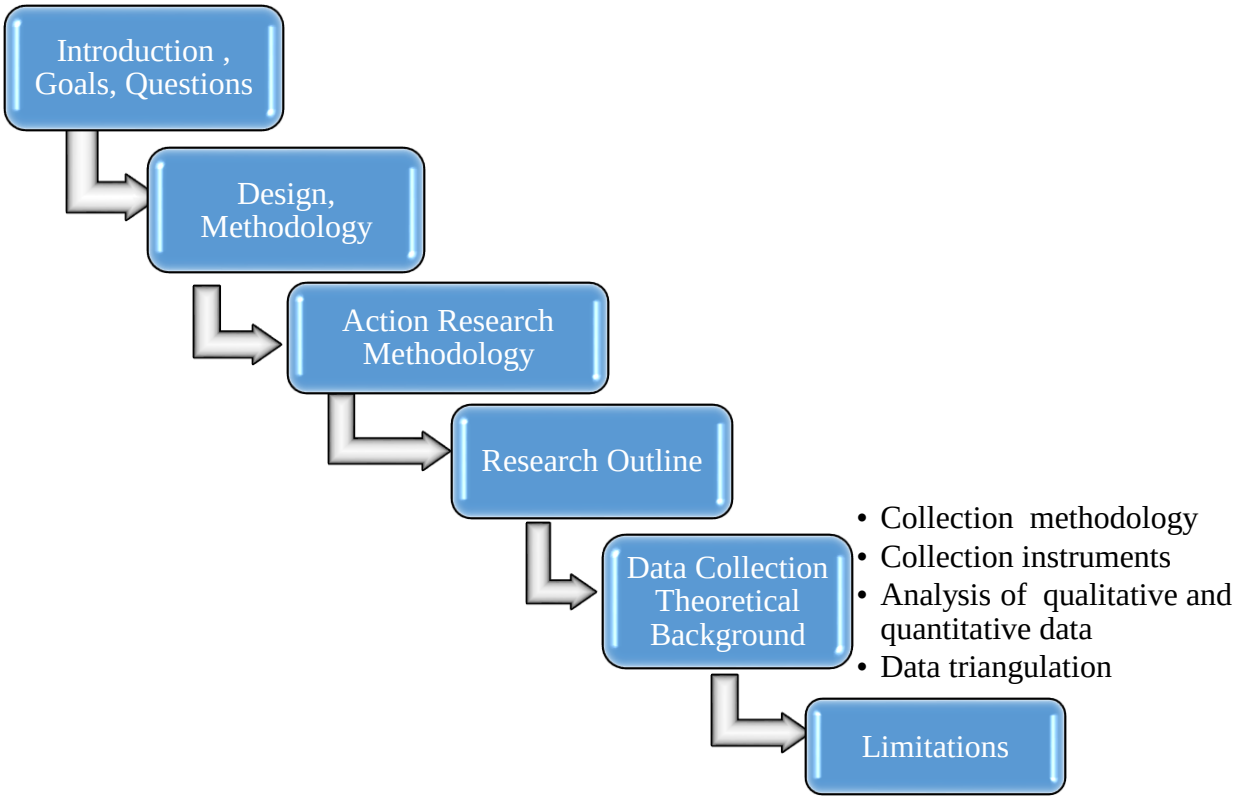


Figure 3.1 Topics discussed within this chapter (Methodology, Chapter 3)

According to Thapa and Saebo (2014), research in the context of ICT4D should not be 'confined to understanding the problem, but should also try to introduce change as well.' (p. 11) The thesis therefore contributes to two intended outcomes: *change* and *understanding.* .

3.2 Goals and Research Questions

This study investigated on-site conditions for using mobile technologies to benefit teaching and learning in higher education in Ghana. The implementation of mobile learning strategies in the field was addressed by identifying aspects influencing integration of mobile devices.

The study was conducted with three goals:

- Investigating the use of ICT in education in a SHS in a sub-Saharan African country.
- Investigating how students in pre-tertiary education can contribute to further developments.
- Implementing changes: development of mobile learning and STEM strategies in education through integration of students.

It is necessary to consider the questions that should be answered in deciding a research design. These include preconditions and local customs to be taken into consideration for enabling mobile learning.

The research attempts to find answers to the major research questions:

Qu 1. What are the most important issues to be taken in consideration when planning the integration of mobile technologies in learning and teaching in a developing country in sub-Saharan Africa?

Qu 2. How can mobile learning be initiated as a beneficial supplement to education in a Senior High School in Ghana?

The following issues are considered in particular:

- What are the requirements for integration of mobile devices in teaching and learning?
- What are the potential barriers to implementation of mobile learning in the context of a public SHS in Ghana?
- How can students contribute to the development of locally relevant content and strategies?

3.3 Research Design, Methodological Considerations

The research design was developed with the aim of constructively combining research interests and local demands. De Villiers (2005) points out that development research is problem-oriented and constantly searching for new and innovative solutions. At the same time, findings that are transferable, practical and socially responsible are sought.

After familiarisation with the relevant literature, the author decided to use an emancipatory action research (AR) approach, as this study seeks local, rather than universal solutions. Action research is driven by the need to solve practical, real-world problems, grounded in the values and culture of participants, and is flexible to local agency. (Denscombe, 2014; Somekh & Zeichner, 2009) AR is a widely used educational research method, based on the aim of improving practice in a structured reflection process in order to effect changes. (Coghlan, 2007, p. 293; McNiff & Whitehead, 2011)

AR effectively combines *action* and *research*, which allows some flexibility, as the research outcome is related directly to the researcher. (Kuhne & Quigley; 1997; Dick, 2002) Participatory action research has the aim of drawing more people into the process as the work progresses.

In order to determine the appropriateness of the research design for this study, the author considered whether the four main characteristics of action research, as defined by Denscombe (2010, p. 127), match the proposed research. The following features supported the use of action research in this study.

- *Practical nature*: This research deals with real-world problems and issues in an organisational setting of a SHS, incorporating teachers and students.
- *Change* is regarded as an integral part of the research and dealing with practical problems. This research focuses on an approach to implementing a new strategy for learning.
- *Cyclical process*: Three workshops within three years, with a break of nearly one year between, provide potential for change. Evaluation and feedback direct further investigations in the following research-cycle.
- *Participation*: This research is emancipatory action research because the researcher is an expert in teacher education, and participants are local students and teachers.

Considering the above-stated characteristics, emancipatory AR was identified as appropriate for the intended small-scale case study, concentrating effort on one research site in cooperation with teachers and students in a sub-Saharan African environment. The researcher is an outsider in this study and may see things from a different point of view than insiders. Insiders often do not realise the importance of some factors. The setting of this research offers alternative perspectives, which can help insiders to gain new insights into the nature of the practical problems involved. (Denscombe, 2010) The cyclic process is suitable for changing situations over a given time interval.

The research was conducted in a Senior High School in Keta, in the south of Ghana. The campus is located close to the sea and hosts school buildings and dormitories; many teachers and the principal live in small villas on the campus. At the time of the research the school hosted

approximately 160 teachers and 2,500 students. 43 teachers and 33 students participated in three workshops, between September 2012 and June 2014, for this study.

Changes were implemented in cycles linked to one another. Method, data interpretation and action were developed concurrently from cycle to cycle. (Dick, 1999; de Villiers; 2005) Interventions, based on a spiral design, allow learning from experience during the spiral process. Each cycle offers an opportunity for continued reflection associated with a focus on improvement.

3.3.1 Action Research - Background

This section provides deeper insights into AR for an intervention-oriented case study. The aim of AR is described, as well as how it is designed and advantages and disadvantages, which must be considered for this study.

Action research was developed in Europe and the USA in the first half of the 20th century, associating social theory and solutions of immediate practical problems. (Denscombe, 2010; Somekh & Zeichner, 2009) Kurt Lewin, who is commonly credited with inventing the term 'action research,' defined AR as a 'participative, cyclic research approach directed towards both research and action'. (Lewin, 1946) AR is an empirical technique for gaining knowledge by means of directly experiencing innovation through developing strategies for achieving an improvement in a particular situation. AR emphasises 'research in action' rather than research 'about action' (McNiff, 2010, Dick, 2002).

Brydon-Miller (et al. 2003) refer to AR as 'a work in progress' approach (p. 11). This specifically practical orientation of action with the reflective process of inquiry and knowledge generation has remained a defining characteristic of AR. (Somekh & Zeichner, 2009) Dick defines AR as a 'flexible spiral process which allows action [initiating change, improvement] and research [understanding, knowledge] to be achieved at the same time'. (Dick 2005, 1999) Somek and Zeichner (2009) point out that this explicit combination of action and knowledge generation is uniquely suited to generating and sustaining transformation, and is a well-suited methodology for educational transformation in the 21st century. Popplewell and Hayman (2012) refer to AR as action-oriented, participatory and values-based (p. 1).

AR addresses the problem of division between theory and practice by integrating the development of practice with construction of research knowledge in a cyclical process. (Somekh & Zeichner, 2009, p 89; Popplewell & Hayman, 2012; Rose et al, 2015)

An advantage of AR is that it addresses practical problems in a positive way by feeding results of the research directly back into practice. AR is research from inside, carried out by researchers working in collaboration with participants. Denscombe (2010, p. 129) points out the crucial characteristics of the cycle of enquiry in AR:

a) Research feeds back directly into practice; and

b) the process is on-going.

In addition, the participative character of AR can democratise the research process, and generally involves a greater appreciation of participants. (Denscombe, 2010, p. 134)

Various authors outline the model for a single research cycle based on three to five stages. The model used in this research is outlined in Figure 3.2 (adapted from Rose et al, 2015[47]). Each cycle is composed of phases: *Plan* (think; define a research problem); after developing a question, a research plan is formulated, *Activity; Data Collection*; *Analysis* of collected data, and *Reflection*.(van Akker, 1999 p. 6.

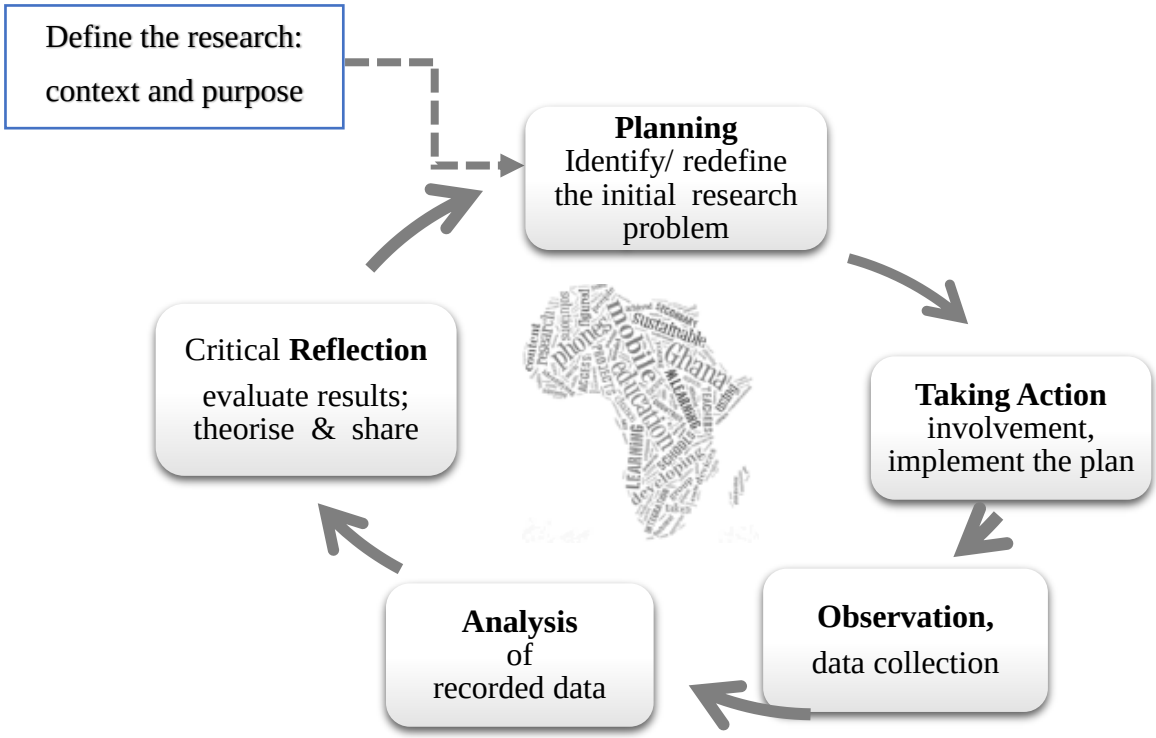


Figure 3.2 Phases of an AR cycle (adapted from van Akker , 1999 and Rose et al, 2015)

In the *planning phase*, the researcher identifies relevant issues in the current situation and develops ideas for improvement, often based on a literature study. Interventions are planned in advance of the action phase, and, if possible, discussed with experts and/or stakeholders. During the *activity phase*, interventions are carried out. Efforts in the *intervention* are documented, *data* are *collected (*observation notes, surveys, reflections, interviews, etc.) and *analysed*. In order to understand the effects in context of the initial research plan, a conclusion is drawn based on a systematic and critical *reflection* of the result of the intervention. This can be complemented with a literature review, discussions and a revision of aspirations. The understanding gained allows for better-informed change and at the same time is informed by that change.

[47] http://guides.lib.byu.edu/stepbystep

A critical review of a situation and past actions can enable a new implementation cycle to improve the process. (Brydon-Miller et al., 2003; p. 11, Dick, 2002) As these cycles of research spiral over time, new questions, new literature and new methods emerge. When the researcher feels the outcome of a particularly problematic situation is already reasonably satisfactory, the experience and conclusions, called 'actionable knowledge', can be reported and discussed with a wider audience. (Coghlan 2007, p. 293) The end of one action research project may lead to research on other situations, which enables research and new implementation cycles to continue. (Brydon-Miller et al., 2003, p. 11)

Dick (2002) highlights flexibility as a main advantage of AR. He states that the research can start with quite imprecise research questions. The cyclic structure allows refinements of the research design during the research process, as deeper insights in the situation are gained. When moving forward, each cycle is required to become more precise.

One of the distinctive features of AR is the participatory nature of the research. This requires that practitioners are participants in the sense of being partners in the research. (Denscombe, 2010, p. 145)

Due to the necessary involvement of the practitioner, a limitation of scope and scale of the research is often criticised as potential disadvantage of AR. This might affect the representativeness of the findings and the extent to which generalisations can be made based on the results.

In summary, action research is a 'participative, qualitative, action-oriented, and emergent' research strategy, allowing 'involvement of participants, which can further increase the diversity of data, and eventually therefore of understanding'. (Dick 2005, Paper 44, p.6)

3.3.2 Setting and Participants

This research was initiated through personal contacts of the researcher and an Austrian NGO, ICT4d.at, which contacted the author after taking note of reports on experiences in Kano, Nigeria, and Cape Town, South Africa. Together with a Ghanaian member of ICT4d, who was studying IT in the UK at the time, we planned an educational activity in Ghana. At the beginning, in summer 2011, we had only a vision of what might be achieved. The planning took approximately one year, and was revised over time, as the research idea evolved with better understanding (details in Chapter 4).

In cooperation with Ghanaian stakeholders, a project plan was developed via frequent Skype conferences and emails. Multiple schools in Ghana were asked if they were interested in the project. Finally, collaboration with a higher secondary school in Keta was established.

An online survey was developed for teacher applications in advance of the first workshop (Appendix 4.3, Application). In order to ensure that participants would attend the workshop, they were asked to pay a minimal fee (15 GHC, ~ 3.50 €), which was returned to the participants

after completion of the workshop (locally carried out by a schoolteacher). The researcher experienced in former workshops that a minimal fee in advance ensures that the enroled participants will attend the entire first course to get the money back. There was no need for a fee in follow-up workshops, in which the participants were locally invited. A total of 40 teachers and 33 students (aged 16-19 years) participated on a voluntary basis in their free time.

3.3.3 Appropriateness of the Methodology

Action research includes collaboration with practitioners in development work, though it is not the only research approach that deals with research in the field of educational interventions in developing countries. (Coghlan & Brannick, 2014) However, participatory action research has turned out to be an ideal method in this specific research and environment. The findings of this research are most notably representative for a similar environment.

3.4 Research Outline

This research presents a longitudinal study to harness the potential of using mobile devices for learning in a Senior Secondary School. In order to gain better knowledge of the local environment in a developing country, the case study involved three action research cycles. In Figure 3.3 cycles, including numbers of participants in the workshops, are depicted.

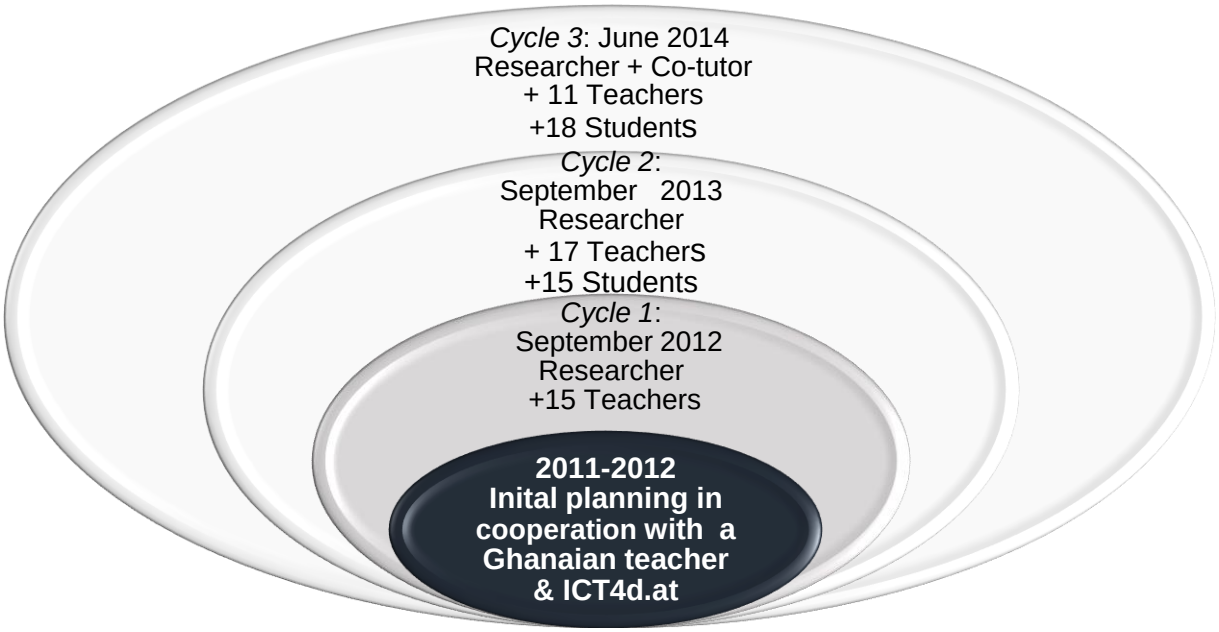


Figure 3.3 Outline of the intervention phases in three AR cycles

The on-site research in Ghana was scheduled for September 2012, September 2013 and June 2014. On-site investigations included three workshops, each of three weeks duration. Each cycle included a period, from the preceding workshop to the following, in which the participants could progress toward the anticipated goals.

Scheduling the project over this period aimed to allow teachers and students to become familiar with new routines and to develop locally relevant investigations in their daily practice in advance of the follow-up intervention. The breaks in the on-site research (workshops) were bridged with emails and frequent Skype-chats with students in order to facilitate on-going activities during these periods. Students informed the researcher with reports about additional activities, some included videos and short statements. It was thus possible to understand changes in order to appropriately increase the complexity and heterogeneity of the subsequent interventions.

The structure of each cycle, with a workshop and time for the participants to carry out their own investigations, promises to enable transformation. The core activity of each cycle was a workshop. Within each workshop, on-site observation was conducted and data were gathered in order to provide suggestions and planning interventions for the follow-up cycle.

The research design was adapted to combine participants' interests and local practice in a constructive and generative way. Various interventions in each workshop were created and implemented to achieve change. (Fig. 3.4)

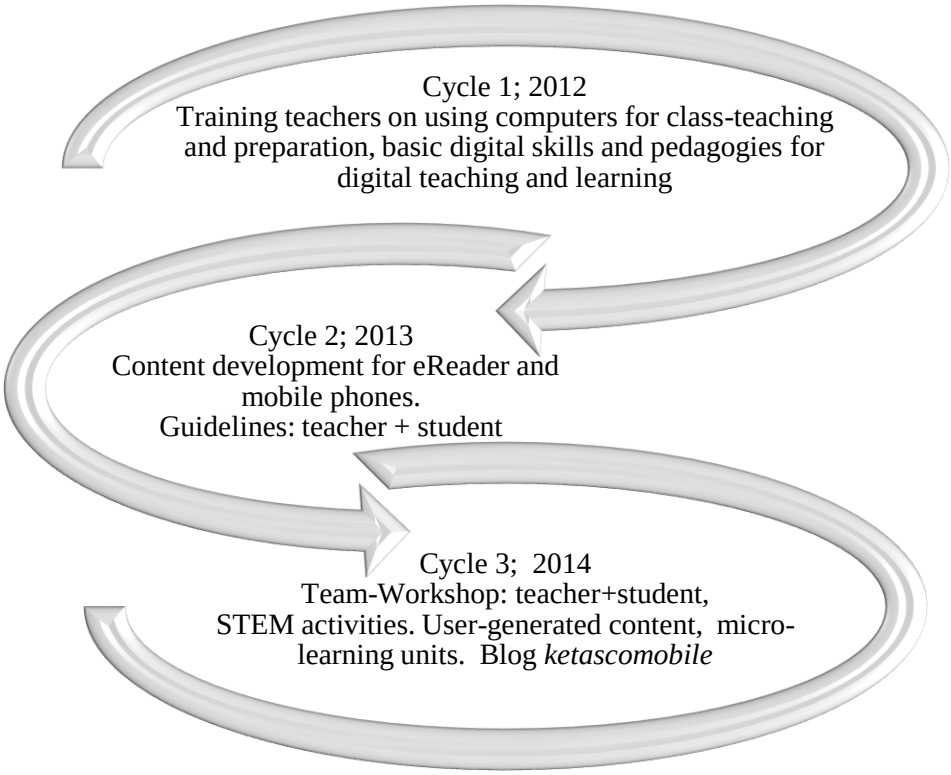


Figure 3.4 AR cycles, addressing the main topics of the workshops (interventions)

Each cycle included a think-act-reflect period. Data collection, analysis and documentation of the activities and outcomes supplemented the workshops. Each cycle generated findings that were used to facilitate the following cycle in order to proceed to a sustainable solution.

3.5 Data Collection and Analysis

A variety of tools, with respect to the AR method as a holistic approach for problem solving, were used over the course of this research. Formative and summative data collection methods used in this thesis include surveys, observations, daily notes and reflections, and semi-structured interviews. Complementary qualitative and quantitative data were obtained.

- Quantitative research was conducted with structured surveys.
- Qualitative research was conducted with semi-structured interviews (one-to-one and small team interviews with teachers, students).

These included:

- Anonymous online surveys (qualitative and quantitative);
- Post-workshop feedback (qualitative and quantitative; individual and in teams);
- Semi-structured interviews, conducted in person, were audio-/video-recorded and transcribed.
- Evaluation of samples of learners' work (projects, portfolios, posters, presentations).
- Annotations, field notes, photographs.

An outline of data collection procedures is depicted in Table 3.1.

May 2012 Planning	September 2012 1st Workshop	September 2013 2nd Workshop	June 2014 3rd Workshop
Development of a pre-workshop survey for application: Area of specialisation Expected personal benefits of participation; Expected benefits for the institution of employment Topics of interest	Online survey for teacher 31 items; 36 responses. Post Workshop Feedback (teacher, free text); 11 responses	Online survey for teacher, 18 items; 18 responses for students, 43 responses Post Workshop Feedback, semi-structured. for teacher, 15 items 12 responses for students, 12 items 13 responses Expert Review (local external examiners) of portfolios and micro-units, project-outcome; qualitative	Online Survey for teacher, 16 items 7 responses for students, 17 items 51 responses Post Workshop Feedback, semi-structured. 9 teacher (future work in class teaching), 20 students; Semi-structured interviews: Teacher interviewed colleagues (18 interviews) and 3 students Students interviewed peers (24 interviews) Researcher interviewed 10 teacher (participants)

Table 3.1 Data collection; method, respondents (Grimus et al, 2014)

Online surveys remained online after each workshop. Data were downloaded and analysed approximately 10 weeks post workshop (to plan interventions for the next cycle).

Data analysis informed the on-going interventions. Data triangulation was considered to get a more complete picture of divers items incorporated in the enquiry. It is in line with recommendations published by Valouva and Sharples (2009). They recommended this method for capturing different aspects of mobile learning perspectives.

Data triangulation in this research combined dissimilar methods, such as surveys, interviews, and personal reflections. The researcher drafted notes during the workshops on a daily base and reviewed the samples in the evenings in order to provide accurate insights in the complete situation. Observations aimed to gather information on attitudes of teachers and students in using ICT and how they interact with devices and tools. Samples of learners' work (presentations, micro-content and portfolios), field notes and photographs complemented the research (see Chapter 4).

In order to meet the aim of this study the evaluation of answers gained in interviews and written feedback were coded under specific keywords (topics) and analysed. The results were categorised, condensed and interpreted, and provided answers to particular key-issues. Quantitative data gathered through the surveys were analysed using Microsoft Excel, qualitative data were clustered into categories and summarised by way of descriptive analyses.

Instead of assessments (formal tests and examinations, as it is mainly used in formal settings) the participants developed personal portfolios during the workshops to track the process of learning. The portfolios were evaluated by the researcher and in a second round anonymously by external examiners. This procedure provides findings that are applicable beyond the immediate boundaries of the study.

3.5.1 Collection Methodology

Since an AR framework involves multiple research cycles, a mixed design for data sampling addresses the research question in more depth. (Teddlie &Tashakkori, 2006) A combination of qualitative and quantitative data collection methods was used to provide a better understanding of the problem and allows a holistic picture of the research. The validity of findings could be checked using multiple sources of information. (Denscombe, 2014)

Analysis of the data is the most difficult, as well as the most interesting aspect of the work. In AR, this is an on-going process, concurrent with reflection during data collection. Data collected during the research process can influence the choice of research methods in subsequent phases. The development of action strategies and their implementation, based on the findings of the initial stage of the research, needs to be followed by further data collection and evaluation.

3.5.2 Collection Instruments

Observations

Observations are for gathering first-hand data, and provide opportunities for identifying unanticipated insights in unstructured and flexible settings. A research journal is a document reflecting the increased understanding that comes with the action research process. In documenting the actual development of the research, it provides a chronicle of research decisions as well as a record of one's own thoughts, feelings and impressions. (Denscombe, 2014) For research, diaries are important in terms of recording things that have already happened (ibid). Within this study, observations were initially drafted and finally structured as a source of documentary on a daily basis (diary).

Surveys

Surveys provide a collection of accurate information with standardised data. Each respondent reads an identical set of questions, which may include questions about both facts and opinions. This allows a speedy collation and data analysis; it is very productive due to the ease of processing answers. (Denscombe, 2010) Responses in an accurately designed survey can be fed automatically into a spread-sheet or data file. This provides pre-coded data that can be easily analysed while offering accuracy in terms of data collection.

Closed questions allow only answers that fit into predefined categories, by selecting from a range of two or more options supplied in the questionnaire. They produce quantitative data (nominal, ordinal, interval, etc.), which can be quantified and compared. *Open questions* require answers in the form of text, which can be treated as qualitative data.

Online surveys allow preparation in advance. Respondents select from a predefined range of answers and simply submit the completed form at one keystroke.

Interviews

Interviews are used to collect qualitative data. They allow respondents the time and scope to talk about their opinions on a particular subject, which is selected by the researcher from areas the researcher is interested in exploring. Interviews as a data collection method are appropriate for the exploration of more complex and subtle phenomena. Opinions, feelings, emotions and experiences are explored in detail, rather than simply ticked or reported briefly in a survey. (Denscombe, 2010)

Structured interviews involve a rigorous set of predetermined questions and offer limited options for responses. Each respondent is faced with identical questions. Thus, structured interviews are, like questionnaires, administered face-to-face with a respondent. The range of pre-coded answers allows the collection of quantitative data, and has the advantage of standardisation, allowing relatively easy data analysis.

Semi-structured interviews are open, based on a framework of themes to be explored (i.e. a list of issues to be addressed and questions to be answered). Semi-structured interviews offer flexibility in terms of the order in which the topics are considered. They allow the interviewee to bring up new ideas and to speak more broadly on the issues raised by the researcher. The interviewee can elaborate points of interest with open-ended answers (ibid).

In *unstructured interviews*, emphasis is placed on the interviewee's thoughts. The researcher starts by introducing a theme or topic, and the interviewee develops his/her ideas and thoughts. (Denscombe, 2010).

Semi-structured and unstructured interviews produce qualitative data. They allow interviewees to use their own words and develop their own thoughts, with the potential for discoveries about complex issues. (Denscombe, 2010)

Audio- or video-recorded interviews

Video recording offers a more complete picture by capturing non-verbal as well as verbal communication during the interview. Transcribing and coding of interview data can cause some challenges, e.g. voices are not always clear, and interviewees do not always speak in complete sentences.

Advantages of interviews

Interviews are a flexible method for data collection that yield data dealing with topics in depth and in detail. They allow the researcher to gain valuable insights based on the depth of the information gathered. Interviewees can expand their ideas, explain their views and identify what they regard as the crucial factors. (Denscombe, 2010)

Limitation of the interview method

Respondents may be asked questions differently when interviews are conducted by different interviewers. The depth of qualitative information may be difficult to analyse (i.e. determining what is relevant and what is not), making it difficult to generalise findings.

3.5.3 Quantitative and Qualitative Data Analysis

Quantitative data analysis generates numerical data that are objective in the sense that they exist independently (no human bias attached). Quantitative data focus on specific variables for generating results from a large statistical sample of highly structured measurable data. The process of analysing quantitative data by using numerical aggregation in summaries and basic descriptive statistics (e.g. tables, figures) is separated from the process of data collection (Denscombe, 2010, Miles et al, 2013).

Qualitative data analysis is the classification and interpretation of linguistic (talk or text) material to make statements about implicit and explicit dimensions and structures of meaning making in the material and what is represented in it. (Flick, 2013) Qualitative data analysis is

non-statistical; it refers to non-numerical data collection, uses unstructured or semi-structured data and is based on inductive reasoning. The analysis of qualitative data is an explanatory approach to gain insight into particular practice (ibid). It is more subjectively influenced by biases of the researcher (opinions, knowledge, assumptions). The major methodological step is to code (categorise) the data by using qualitative content analysis.

Qualitative data analysis can answer important questions more efficiently than quantitative approaches. (Miles et al, 2013) Because qualitative analysis draws on the interpretive skills of the researcher, it allows alternative explanations.
In educational research, qualitative data are considered more trustworthy and informative. Including qualitative elements in this research minimises the weakness of using a single research method. According to Denscombe (2010, p. 206), extracts of transcripts play an important role in qualitative research. Semi-structured interviews were therefore extensively used in the final cycle of the research (see Section 4.6.7)

3.5.4 Data Triangulation

Data triangulation refers to collecting and comparing multiple types of data in order to minimise ambiguity in findings by viewing things from different angles. (Somekh & Zeichner, 2009) Denscombe (2010) states that bringing more than one kind of data into a process provides some objectivity and distance. It adds confidence for the data analysis with regard to better knowledge of the problem. The opportunity to underpin findings and to view things from more than one perspective can enhance the validity of the data (ibid). Triangulation is also recommended, because semi-structured and unstructured interview methods tend to produce non-standard responses. Interview content can be checked against other interviews to see if there is some level of consistency. (Creswell, 2013)

An action research design includes particular data collection and interpretation. Later cycles can therefore test both data and interpretations from earlier cycles. (Dick, 1999)
This study uses a triangulation approach in which two main research methods are used:

Qualitative methods:

- Observations during the on-site phases (teachers and students)
- Interviews with teachers and students;

Quantitative methods used

- Surveys administered online and offline.

3.6 Limitations of the Research

The study faces two important limitations, namely sample size and researcher's nationality.

The research draws on a specific focus, namely the attempt to integrate mobile learning activities in a Ghanaian school. The study is limited to one Senior High School (SHS) in Keta. The small-scale research and the description of the findings is based on both qualitative as well

as quantitative research scores, and deals with complex social situations. The sample size involves 40 teachers and 33 students participating in the workshops; the school hosts approximately 2,500 students and 160 teachers and staff. However, residents on the campus (teachers and students) contributed in informal discussions of deeper insights into the local situation.

The main interventions were limited to workshops. One of the most significant conclusions to be drawn from the literature review is, that no instrument for measuring how the intervention has changed the practice in school and students learning could be identified. For this reason, an outcome of student developments, which is normally related to a semester-periods, is not scalable.

Furthermore, action research is sometimes criticised as a method in which findings are related to a specific case and might not be suitable to be generalised, and action researchers are not neutral actors. (Popplewell & Hayman, 2012)

According to Denscombe (2010), a researcher is commonly recognised as a crucial measurement device; a researcher's background, values, identity and beliefs might have a significant influence on the collection and analysis of data. The intervention of a European researcher in the school practice of Ghanaian teachers and students presents a variety of ethical issues and limitations. Pedagogy and teaching, including teaching material, is very different from European customs, which form the researcher's background.

Planning the on-site research was conducted from abroad, in cooperation with two Ghanaian colleagues. Because the researcher lives in Central Europe, the on-site studies were performed within limited timeframes. In the periods between the workshops, on-going developments were monitored via Skype, Chat and emails, mainly with students from KETASCO. The communication is still on-going at the time of writing (see 5. 8), which provides the opportunity to observe sustainability of the project.

Because the research is impacted by the limitations mentioned above, this might result in reduced transferability of the findings. However, the researcher anticipates that the findings will contribute to broaden research on the impact of mobile learning and ICT in education in sub-Saharan Africa.

3.7 Summary and Conclusions (Chapter 3)

Participatory action research was decided to be the most appropriate methodology for this study. The research encompassed a variety of methods and tools during the progress of the study. Data collection and analysis were conducted within single cycles. Methods were refined based on the developments and reflections on the analyses in each cycle, in accordance with background theory of the various methods.

4. Research Process

This chapter provides deeper insight into the phases of the research process. The research focuses on two intended outcomes: developing understanding and changing teaching and learning. The activities addressed the topics and issues outlined in the literature research, as outlined in Chapter 2.

4.1 Planning the Research

Relevant issues for conducting this study on mobile learning in a developing country were identified based on an extensive literature review on the topic of ICT and mobile learning in the context of sub-Saharan Africa (see Chapter 2). The main factors primarily to be taken into consideration are outlined below (Grimus, Ebner, Holzinger, 2013):

- Government/school authorities: education and policies in Ghana; curriculum for higher secondary education; school equipment (computer-lab, Wi-Fi connectivity; maintenance/replacement of hardware; device/network management; legal aspects, e.g. guidelines for appropriate use access.
- Infrastructure, technology: Internet access, mobile networks, connectivity, Wi-Fi, bandwidth, mobile devices (smart phones, feature phones, other devices).
- Teachers: methods in teaching classes, digital literacy, knowledge about and evaluation of online content, use of devices; teacher education.
- Learners/students: digital skills (digital literacy, digital reading); access to digital devices (ownership/sharing; affordability of data plans), access to the Internet/offline use of content; interest in specific topics.
- Learning: formal learning (schools), informal learning (self-motivated); peer group learning; cooperation with peers; language (English).
- Content: appropriate locally relevant content, free access to educational content; special offers.

With interrelated issues in mind, two primary research questions were formulated (see 1.5.2).

Qu1: What are the most important issues to consider when planning the integration of mobile technologies in learning and teaching in a developing country in sub-Saharan Africa?

Qu2: How can mobile learning be initiated as a beneficial supplement to education in a Senior High School in Ghana?

4.1.1 Considerations and a First Attempt

The complexity of issues, potentially relevant to the research process, was sketched out, as reflected in the structure of the mind map prior to the first on-site research (Figure 4.1).

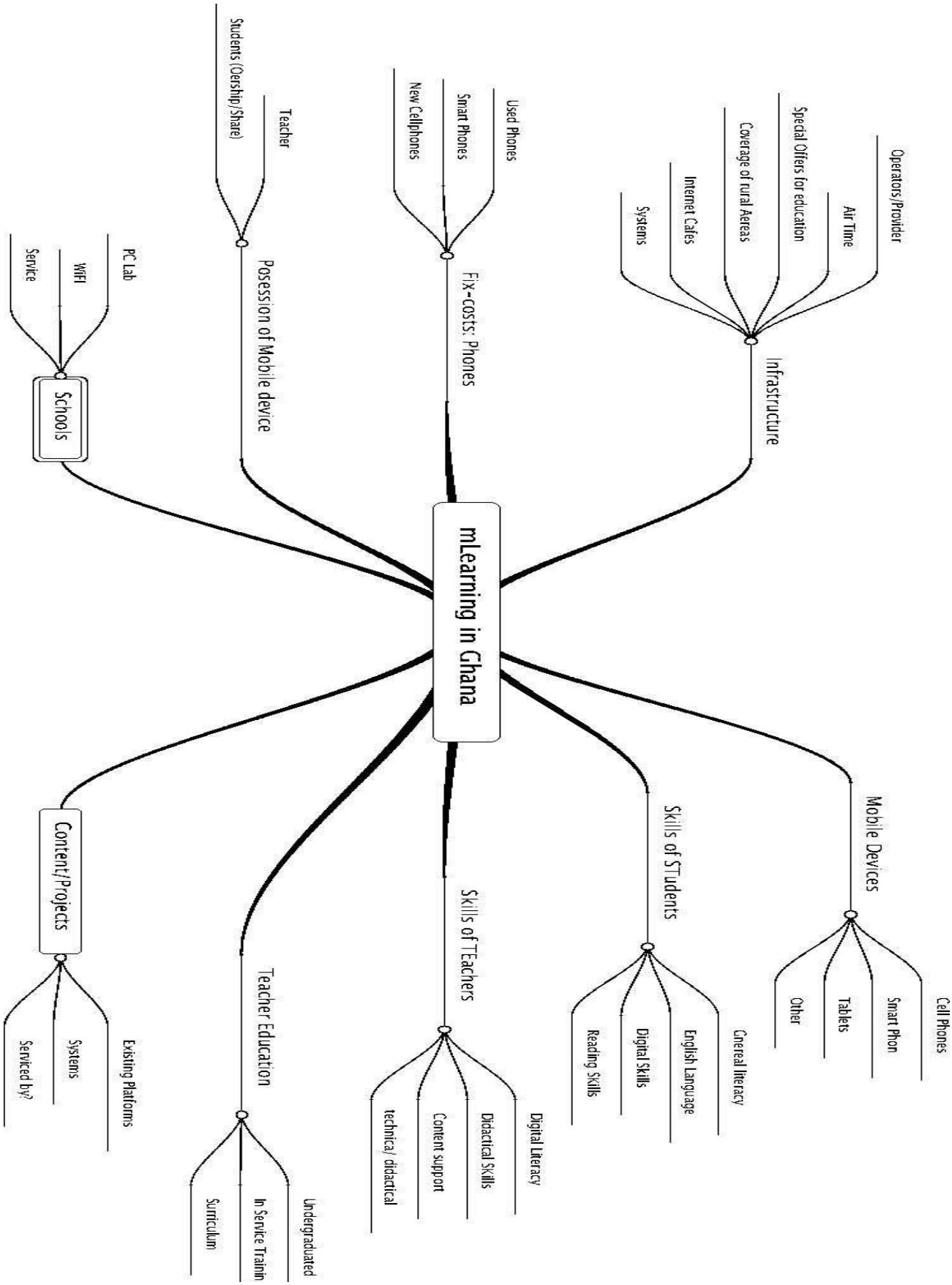


Figure 4.1 Interrelated issues in planning research on learning with mobile devices in Ghana (Source: Grimus, Ebner & Holzinger, 2013)

The author was eager for the opportunity to submit a paper on the present research idea in advance of the first on-site study in Ghana to the mLearn conference in Helsinki, 2012. The aim of the contribution was to draw a preliminary picture of the situation and interrelated facts. The development of the paper helped to identify significant and corresponding issues in the field of the research that may have an influence on the topic of mobile learning in a developing country. The conference was scheduled immediately after the first on-site activity in Ghana and the paper was accepted before. The conference offered the author a chance to discuss recent insights with international experts in the field of mobile learning. The discussions were most helpful and influenced further research.

4.2 Research - Outline

Starting with new teaching and learning methods theoretically and in a short-term project cannot be expected to contribute to long-term sustainable change. Thus, the research was planned for a period of three years in order to truly scope out the situation. The author's experience, gained in previous projects in Nigeria and South Africa, has shown that change can only occur when those affected have a chance to co-create the implementation. Real change depends on involvement in the local and social environment, and can only be realised when those involved have the chance to mould the activities to suit the social realities.

This research covers three action research cycles (AR), referred to as cycle one, cycle two and cycle three in this chapter. Interventions were implemented in each cycle in order to achieve change and included a workshop (WS) at a Senior Technical High School in Keta, guided by the author. The workshops are central aspects of each AR cycle. Figure 4.2 depicts the main focus and participants of the three interventions in the research cycles. .

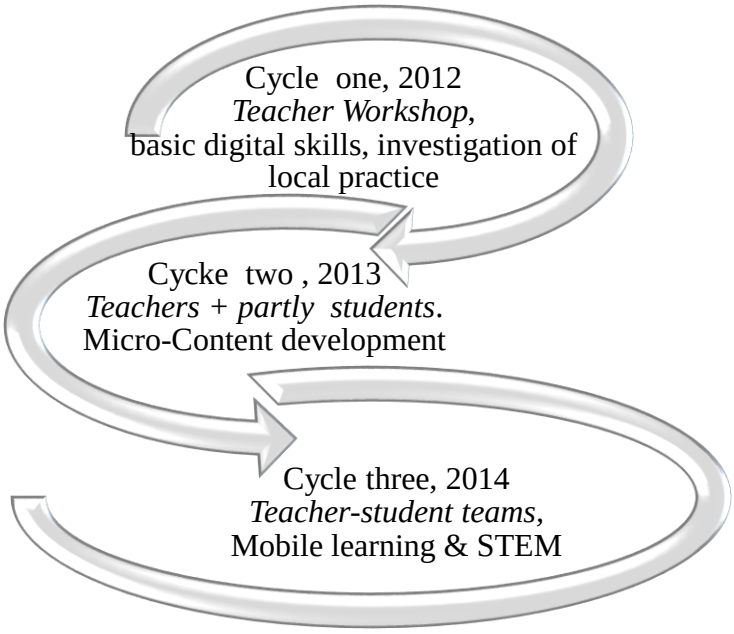


Figure 4.2 Research focus and participants addressed.

The three-year duration of the research project allowed accommodation of social realities and expanded participants' opportunities to gain experience and practice between workshops. Participants needed time for unguided experimentation with newly learned strategies, followed by another intervention including reflection on their experiences. The research evolved as the study progressed over the cycles described below.

The cycles correspond with three consecutive approaches for teaching and learning as outlined in the UNESCO ICT Competency Framework for Teachers (UNESCO 2011).

- *Technology* Literacy: utilise ICT for teaching and learning. (Cycle 1)
- *Knowledge Deepening:* enabling teachers and students to obtain a better understanding of their curricular topics by bridging theories with real-world problems. (Cycle 2)
- *Knowledge creation:* enabling students and teachers to co-create new knowledge required for prosperous societies (e.g. STEM). (Cycle 3)

Adapted from UNESCO 2011, ICT

4.3 Field-Research: Workshops (WS), Overview

The workshops attempted to identify workable interventions in order to improve learning in a public Senior Technical High School. KETASCO is a second cycle institution (SHS), located in Keta close to the south coast. The school has existed since 1953 and presently has a population of around three thousand students. The school was rated in 2016 as one of the '10 Best Secondary Schools In Ghana [in] The Last 10 Years', according to SSCE Scores [48]

Workshops in Ghana could only be organised once a year.

Schedule of the three on-site research phases

First on-site intervention, September 5 – 26, 2012
Second on-site intervention, September 6 – October 3, 2013
Third on-site intervention, June 6 – 30, 2014

Workshops 1 and 2 were held during school vacation time, five hours/day, five to six days days/week.

The last two weeks of the third workshop were scheduled during school time from 6:00 to 8:00 am, continued after school from 5:00 to 8:30 pm.

For the third intervention, an Austrian IT student assisted as co-tutor; he had just finished his Master's degree at the University of Technology in Vienna.

An outline of the three workshops is displayed in Figure 4.3:

[48] http://omgvoice.com/lifestyle/10-best-secondary-schools-ghana-last-10-years-according-ssce-scores/, accessed 23/8/2016

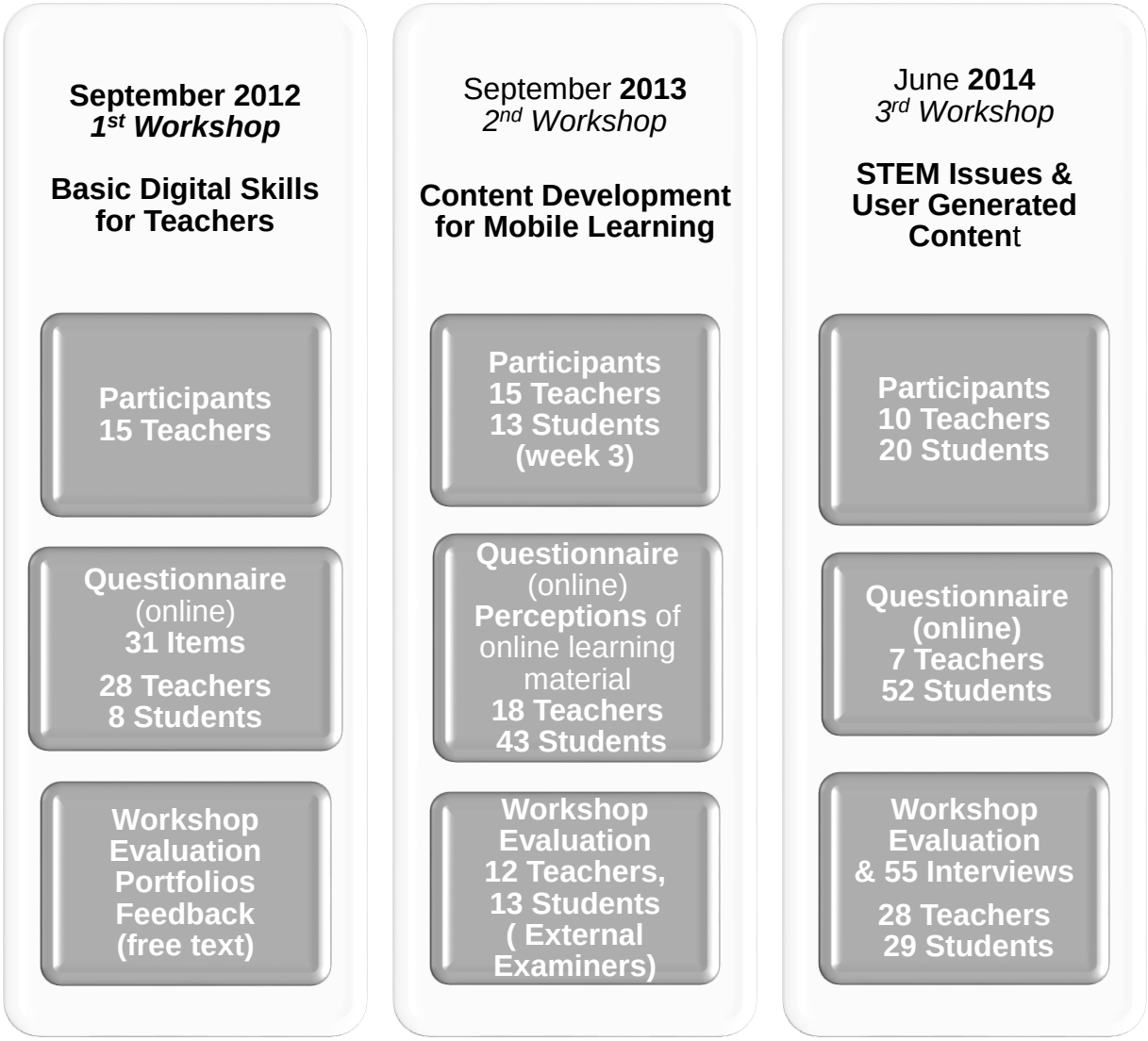


Figure 4.3 Workshop Outline: topics, participants (adapted from Grimus & Ebner 2016*)*

Participants

A total of 40 teachers and 33 students (16-19 years old) participated in the workshops.

Data collection

Data, gathered in each cycle are based on both quantitative and qualitative research. Data collection was carried out with observations, qualitative interviews, post-workshop surveys and quantitative questionnaires during the three workshops.

- Online surveys were developed using the tool Soscisurvey (https://www.soscisurvey.de) for collection of qualitative and quantitative data in the workshops; in total 61 teacher- and 95 student- responses were evaluated with three online surveys.
- Post-workshop surveys (qualitative and quantitative) were conducted immediately after the workshops.

- Semi-structured and audio- or video-recorded interviews were performed in the third workshop; 55 interviews were transcribed verbatim. The outcome of short interviews, occasionally conducted in WS 1 and WS 2, is included in the evaluation of observations.
- Observations were undertaken in an unstructured manner and recorded as field notes. The author participated and observed at the same time in the position of an insider-observer, holding an active role in the entire study process.

While the author is conversant with ICT in teacher education, she was not familiar with the situation in an African school. Observations evolved spontaneously without prior planning, to take note of what occurred in the workshops and outside on the campus, and from listening to communications and experiences of students and teachers. Rough notes of any significance were summarised in a diary; photos taken from the whiteboard aided recall of particular activities (notes were in German, the author's mother tongue). Short videos were taken from specific course topics. In the evenings, rough notes were revised and clustered (key topics). This, together with photos, helped to complete the observations. The aims and data collection of the particular workshops are outlined in Table 4.1.

Activities	Aim of the Workshop	Data Collection
1st Workshop	To determine the ambitions and skills and of teachers for integrating ICT in teaching in a developing country context.	Mixed methods; data collection consisted of quantitative and qualitative methods.
2nd Workshop	To study how collaboration of teachers and students can affect tasks of content development in a developing country context.	Obtain data about the expectations and final satisfaction of the participants. Data collection consisted of quantitative and qualitative methods.
3rd Workshop	To study the effects of mobile-adapted learning material on learning opportunities, and integration of STEM activities.	55 Interviews were conducted to gather qualitative data about the perceptions of implementing new learning modes with mobile devices, in addition to feedback and surveys.

Table 4.1 Workshops: aims and data collection

4.4 Cycle One, 2012.
Teacher - Professional Development

The first cycle (Figure 4.4) was more exploratory than the others were. The most important issue was to investigate on-site conditions, aiming to draw a realistic picture of the situation. Research focused in particular on the overall situation in the school, conditions of access to devices and the Internet, and teachers' perceptions and abilities for integrating learning with mobile devices.

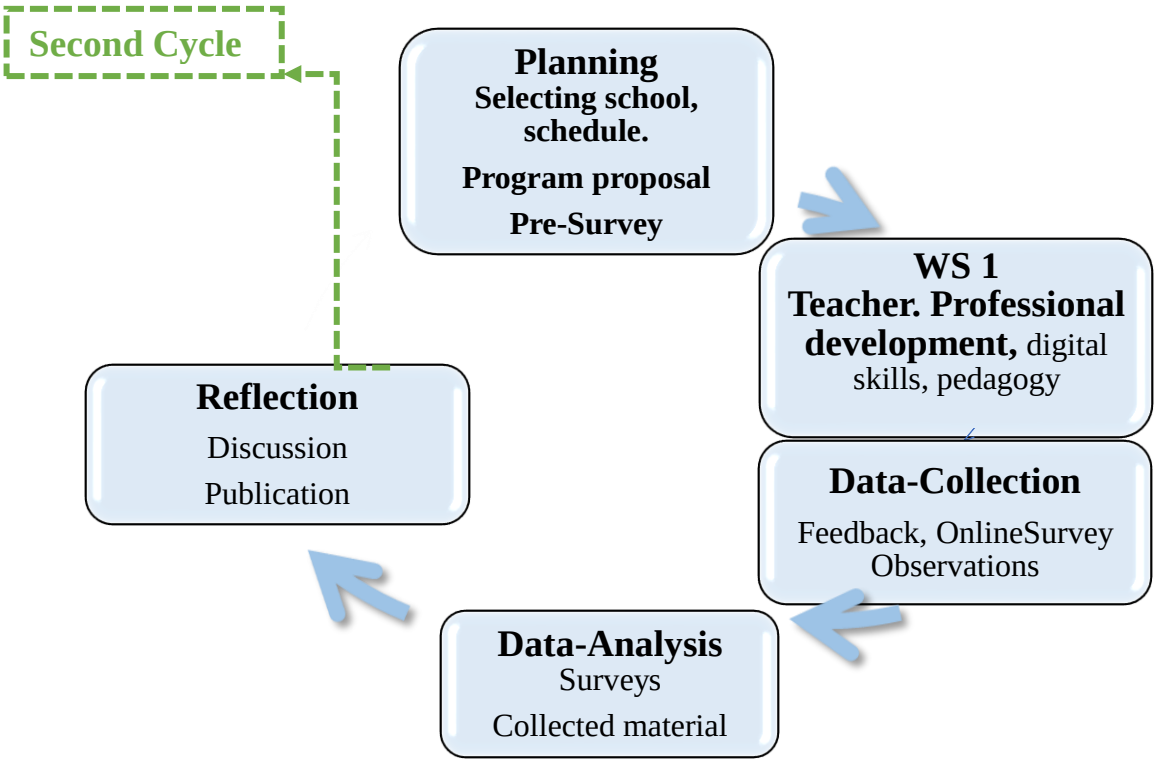


Figure 4.4 AR Cycle 1: Focus, digital media skills for teaching

4.4.1 Planning the First Workshop

The aim of this workshop was to study how teaching and learning can be enhanced by using ICT for preparation and in-class teaching. In particular, it addressed teachers' perceptions of ICT adoption in a public school. In order to find support and interest from teachers and principals in the project, a Ghanaian colleague discussed possibilities for workshops with stakeholders in the Ghanaian school authority. During the planning phase, communication with the author took place via Skype. A working computer lab and Internet access were necessary preconditions for the workshop; it took approximately half a year until the local team was successful in selecting a public school for the research.

A proposal for the workshop programme was submitted to the school principal of KETASCO, who had agreed to host the workshop for teachers. (Appendix 4.1 Project Proposal V3 2012, Appendix 4.2 Official Invitation Letter 2012)

The provision of a computer lab with 15 computers and an Internet connection (via modem, activated during the workshop) was agreed, and a schedule for the workshop was confirmed.

In order to get a rough impression of teachers' expectations, a pre-workshop questionnaire was developed in the form of an online application and an additional printed version (Figure 4.5)

In-service training for teachers in digital media skills for teaching and learning in public schools in Ghana

Application Form

This pilot In-Service Learning Opportunity will be held from Monday _____ at Computer lab, Keta Senior High Technical School, Keta, V/R Ghana.

All applicants to the courses on digital media skills for teaching and learning have to fill in this application form which will be considered by a committee that selects the course participants. All applicants must be resident in Keta Municipality.

Figure 4.5 Header of the Pre-Workshop questionnaire for teachers (Appendix 4.3, Application 2012)

Besides personal data, questions were asked about expectations with regard to expected personal benefits (digital skills), benefits for the school in which the applicants are teaching and particular topics of interest. (Appendix 4.4. Eligibility and responsibility for application)

Eligibility criteria for the application (in original wording of the local organising teacher):

- being basic computer literate and conversant with browsing the Internet;
- have regular access to a computer (ownership of a computer is an advantage);
- being competent in the use of the English language;
- have an active personal e-mail account;
- being passionate about using ICTs to enhance teaching and learning;
- being a public school teacher, resident within the Keta municipality.

Acceptance of 15 teachers, who were encouraged to pass their skills on to students and colleagues afterwards, was agreed.

4.4.2 On-site Activity. Delivering In-service Training for Teachers

The main objective of the workshop was to motivate teachers in a public school to develop pedagogical attempts for integrating digital material into teaching practice. In particular, basic digital literacy with a focus on pedagogy was addressed to improve learning conditions.

Schedule

The workshop was scheduled in September 2012, at the end of school vacation when final exams were finished and teachers were available without competing lectures.

Proposed learning objectives:

- Using a computer for lesson preparation, research and class-teaching;
- Develop skills in using the Internet as a resource to improve teaching and learning;
- Acquire presentation skills to develop and present additional teaching material;
- Identify good practice in using digital devices.

Participants

Based on completion of the application-form, one female and 14 male teachers were accepted for participation.

Demography: eight were aged between 25 - 35 years, five between 36 - 49 years and two were older than 50 years.

Status: eleven teachers held a Bachelor's degree, two a Master's degree, and two a diploma in education. Subjects taught were Biology, English, ICT, Religious and Moral Education, Basic Design and Technology, Pre-Technical Skills, Mathematics, Physics, Science, Agriculture, Government & Social Studies, Woodwork and Technical Drawing.

The Ghanaian teacher who had locally organised the workshop participated by assisting in logistical and technical support, together with one final-grade student.

Workshop – Topics (programme, confirmed with the principal)

- Pedagogy and didactics to enhance teaching and learning; using ICT for preparation and in-class teaching.
- Improving personal computer skills, individual practice.
- Development of a personal digital portfolio (to recap learning outcomes).
- Content development and presentation: best practice; layout, structure; slides, posters, worksheets, images, spreadsheets, visualizing data (tables, graphs, diagrams to explain facts offered otherwise mainly in textbooks, to improve understanding of different topics).
- Internet skills for teaching and learning (resources in English language).
- Legal and ethical aspects, best practice: downloads and copyright, safety and security issues, communication.
- How can the Internet be integrated into in-class teaching to improve learning?
- Search strategies, selection and validation (text, images, videos, experiments); development of link lists for self-conducted learning. Due to scarce Internet-connectivity, this topic was mainly theoretical discussed.
- The evaluation of Open Educational Resources (OER) had to be postponed due to lack of Internet connectivity.

4.4.3 Data Collection

A mix of questions in surveys and feedback forms were gathered (Table 4.2):

Collection/Sample	*Analysis*	*Source*
Observations, feedback, individual discussions 4.4.4.1	qualitative	Journal notes, reflective diary: meetings (school principal, Ministry of Education in Accra)
Post-workshop feedback, 4.4.4.2	qualitative	Some written by hand, some in print
Survey 4.4.4.3	quantitative, qualitative	Online questionnaire
Individually developed material 4.4.4.4	qualitative	Portfolios, worksheets, posters, presentations

Table 4.2 Data Collection, AR Cycle 1

4.4.4 Data Analysis and Interpretation (WS 1)

4.4.4.1.. Observations, aggregated into key topics

Teachers' Digital Literacy

The level of digital skills varied widely. Although the participants had confirmed basic ICT skills in the pre-questionnaire, it was observed that self-evaluation did not reflect participants' skills in a meaningful way. This is in accordance with Hindelang (et al, 1981), who stated that self-report data are not always a reliable indicator of true individual perspectives, feelings, and behaviours.

The majority of teachers showed scarce experience with a computer. Only a few teachers had basic skills in using the Internet for lesson preparation; most common skills were in texting and participating in Social Networks (Facebook). Deficits in basic terminology, file management and search strategies were observed. Creating a worksheet independently or developing a meaningful portfolio turned out to be a hurdle for the majority. All teachers used mobile phones for phone calls (receiving calls during lessons) and could access mobile Internet. Some teachers copied videos from presentations in the workshop in order to inform colleagues.

Infrastructure, maintenance of computers and network

Poor infrastructure turned out to be a major challenge. There was no Internet connectivity during two thirds of the course. Internet connection could only be established a few times during the very last days. Bandwidth was insufficient; if more than three users were online, the connection failed. Moreover, power supply was a severe challenge; many unforeseen power

outages interrupted the work. Nobody could predict their duration; outages could last from hours up to more than a day.

Meeting with stakeholders

In order to gain additional perspectives on the project, two meetings with the school principal were arranged in the last week. Thereafter, a meeting at the Ministry of Education (MOE) in Accra was organised. The impact and achieved outcome of the workshop was discussed with a delegate of the ministry, the school principal and two teachers. A continuation of the project was agreed. Support with maintenance of the computers and substantial improvements in Internet connectivity were promised for the next workshop. The installation of a solar power supply was discussed as an option for future improvements; however, this did not become reality in this research.

Discussions with students

A teacher's family on the campus hosted the author. This enabled discussions with groups of students interested in what was going on in the computer lab. The students showed high interest and recorded videos of discussions in order to share the debates with peers. Sometimes other teachers (not course participants) came along and asked what was going on. Most teachers left after recognising that the discussion is about ICT and learning; they were not interested in new learning ideas.

A summary of the findings is outlined in Table 4.3.

Main Issues	*Findings*
Teachers: Digital literacy	Majority of teachers demonstrate only basic experience (mainly in text processing); low knowledge of terminology Internet skills: low (Google search),
Teaching methods Learning material	Rote learning dominates, Scarce books, often outdated
Infrastructure	Electrical power is a challenge; daily blackouts Weak Internet connectivity and Wi-Fi coverage
Computer lab, Equipment	15 PCs (not up to date), poorly maintained (no updates in virus detection); basic level of network security implemented, Software: MS Windows and MS Office
Meetings with the school principal	Principal was very interested; during a general assembly, he encouraged the staff and all students to keep on track with digital competences.
School Authority (MOE)	Support for infrastructure improvements was proposed by the Ministry of Education
Students	Students on the campus showed high interest in applications for learning with their mobile phones. They were familiar with video-recording discussions and using social networks.

Table 4.3 Findings of observations, clustered in categories

4.4.4.2.. Post Workshop Feedback

Participants completed a post-training survey on the last day (MS Word). The aim was gathering knowledge about the impact of the workshop. Feedback was targeted to how the workshop changed teachers' views on ICT integration in classroom practice and their personal appraisal of improvement in digital skills. (Appendix 4.5 Teacher feedback, example) Unfortunately, it was not possible to save all feedback on pen-drives due to a virus attack followed by power outage. Teachers were asked to compensate for this challenge; eleven pieces of handwritten feedback were gathered. Key issues from the feedback are clustered and condensed into three categories, including some statements in original wording (*in italic*).

Professional benefits

All respondents outlined use of digital tools to improve teaching as well as learning outcome as a benefit. *Students receive quality-learning materials without extra costs.* A reason for the benefit was mentioned as: '..,*can enhance quality in class-teaching and lesson-preparation'*. Internet for lesson preparation was remarked on as a support in the organisation of lesson planning. Further comments addressed presentations: '*can enhance visual associations through use of images and graphics'; 'impacting knowledge by implementing videos, texts, pictures, images, audio*'; evaluation of online information, has '*positive impact on the cognitive, affective and psychomotoric domains of students*'.

Further statements: 'I am now guiding students how to use search engines more effectively for research and statistical data.' 'It helped me to teach my students how to meet professional standards (layout, organise and structure content: text, presentations), calculations for easy comparisons.' 'I can provide students with access to actual information about different issues, so they will perform better in exams.' 'It helps me a lot in development of my basic ideas of ICT in education.''

Institutional Benefits

Transfer of experience to teacher-colleagues: 'Ability to explain to others the role of the Internet for the growth and development'. 'I can train other teachers in digital skills that can affect student's outcome'; 'I can represent the school during inter-school meetings of teachers'; 'I can write now for a digital audience'.

Claims

Requirements for improvements in a follow-up workshop were nearly identical in all of the reviews, e.g. improving maintenance of the equipment in advance, including virus detection updates and removal of potential threats. Improvement of Internet connectivity, sufficient bandwidth, and a stable power supply were major demands.

4.4.4.3.. Online Survey

An online survey (31 items; Appendix 4.6 Online Survey 2012) was created for collection of qualitative and quantitative data. Workshop participants were asked to invite colleagues to respond to the survey. The survey featured various question types, including some that allowed participants to expand upon their responses.

Categories of the survey:

- Devices: ownership, category, mobile phones, Internet access & use (10 items);
- Teaching profession, use of mobile content (9 items);
- Demographical data (7 items);
- Open questions: mobile learning, benefits/challenges for teachers/students (5 items).

Outcome

36 respondents completed the survey (missing items were mainly related to age and teaching experience). Details of selected items are presented below.

Demographical data

13 respondents were younger than 30 years of age, four between 31 and 40 years, and 14 older than 40 years; 12 had less than 10 years of teaching experience, 7 had more than 15 years. Subjects taught covered a wide variety of topics, with a majority of respondents being science teachers (Mathematics, Physics, Chemistry and ICT).

Ownership of devices, *Internet access* (Table 4.4)

Ownership (multiple answers possible)	n =36	
Mobile phone	31	86%
Computer (desktop/tower)	20	56%
Laptop/netbook	27	70%
Tablet	5	14%
Digital camera	14	39%
Other (Kindle, iPod)	2	6%

Type of mobile phone (selection)	n =31	
Smart phone	15	48%

Internet access with mobile phone	n =31	
Yes, always	24	77%
Only via Wi-Fi	4	13%
No access to the Internet	3	10%

Table 4.4 Teachers' device ownership (multiple answers); Internet access (2012)

32 respondents (89%) owned at least one computing device (PC, laptop or tablet); only four (11%) replied neither to own a PC, laptop or tablet. 14 (39% of the sample) asserted that they own both a PC and laptop; two had an additional tablet.

Perceptions towards integration of learning material on mobile devices:

'Would you agree that having learning material available on your mobile device would be beneficial a) for your teaching? b) for students' learning?' (Figure 4.6)

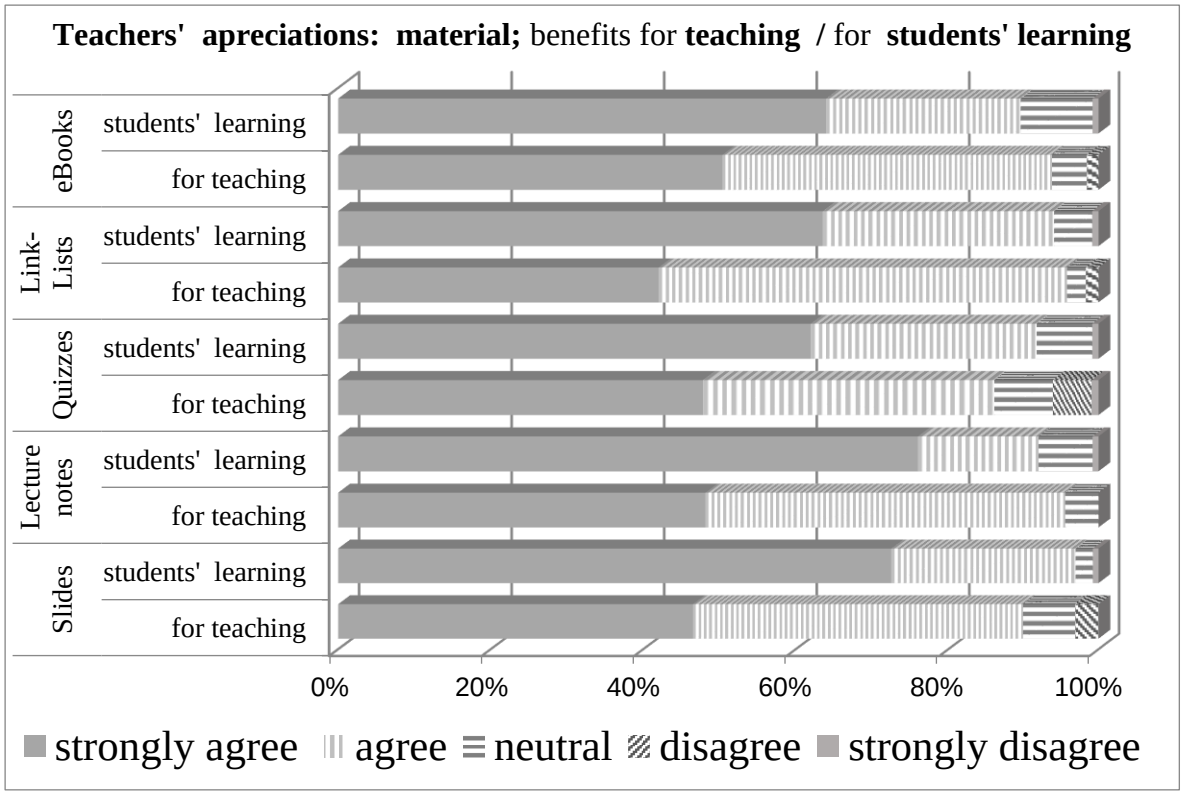


Figure 4.6 Learning material available on mobile phones; perception of specific items, a) for teaching, b) for students' learning (2012)

Nearly all items (besides eBooks) are higher ranked to benefit teaching as compared with the benefit for students' learning.

A five-point Likert Scale is preferred for gathering reactions based on perception in this research. For each of the statements there exists an obligation to classify with one of the five categories: strongly agree/ agree/ neutral/ do not agree/ strongly disagree; answers were scored, score maximum = 5. The calculation of the relevant Likert-grades draws an even clearer picture. The perceptions of using digital material to improve teaching and learning represent a very positive acceptance, as displayed in Table 4.5

Course Material	*Likert Score for teaching*	*Likert Score for students' learning*
Slides	4.50	4.17
Lecture notes	4.43	4.33
Quizzes	4.27	3.83
Link lists	4.48	4.22
eBooks	4.29	4.30
Likert Average	4,4	*4,2*

Table 4.5 Likert scores: teachers' perceptions, digital material a) for teaching b) for students' learning

The responses to the question

> Investing personal time for learning to use and install software that could make resources for teaching available on a mobile phone?

Shows the willingness of the teachers to install resources for use with mobile phones, which scored with 4.55 Likert grades.

Open questions:

Benefits and challenges of learning with mobile devices (answers categorised into key arguments).

- Benefits for students

Availability and affordability

Learning content is easily available to students at their own time and convenience, on the move; this and affordability of access to appropriate content are major benefits. '*They will always have their course content with them where ever they are, since most of them like carrying mobile phones around.' 'Makes communication easier and helps to store and retrieve information.'*

Better worldview

Most common answers addressed enhancing research options, widening the possibility for gaining better insight into recent developments not available in textbooks, or assists students to prepare for assignments. Further statements: *'Interactive study material and videos, experiments, images could make concepts clearer [ ] relieves boredom and bulky textbooks'. …'broadens their horizons and increases the urge to study a specific subject with a wider scope.'*

- Benefits for teachers

It allows for integrating new ideas and topics in the curriculum: It facilitates teaching by adapting material for class teaching, besides easier access to relevant, reliable and up-to-date information (topics not available in textbooks, research). It can increase creativity, improves productivity, is easy for dispensing information to students ('reduction in burden'). Immediate transmission is also recognised as a benefit, e.g.: send lessons-material or quizzes to students irrespectively of where the students live, send/review assignments, quick update of references and reminders: 'send the course content easily to students and take feedbacks from them, anywhere any time. This will reduce the cost of paper, chalk and other writing materials.'

Personal and professional development: Access to further training material and information retrieval help to 'exchange and cooperate with colleagues'.

- Challenges for students

Use of mobile phones distracts attention in class with abusive usage and misapplication of content, misuse, temptation of use for irrelevant purposes (social networking):. Further

challenges named are access and costs: connectivity costs are main challenges together with interruptions in connectivity, lack of electricity for recharging, high-end device costs, inability of some parents to afford a required phone. *'In Ghana mobile devices / phones are not allowed in Secondary Schools.' 'Students are likely to engage more in social media platforms at the expense of the learning content sent to them'.*

- Challenges for teachers

In the school (outside computer-lab) there is no wireless connection, and Internet connectivity is poor. Other obstacles mentioned are the lack of support and maintenance, lack of appropriate content, insufficient OER for Ghanaian curriculum and syllabi (no local content developers), lack of knowledge about requisite software. Further challenges are financial pressure, affordability; cost of acquiring devices with capacity to use mobile applications becomes a heavy burden. An interesting aspect mentioned was: '*teachers receive phone calls and messages on unnecessary issues during class teaching*'. Another dimension of challenges is rrelated to teachers' readiness, privacy, lack of skills among teachers, and refusal to accept mobile learning.

Recommendations of devices for integration of mobile learning in Higher Secondary education:

The majority suggested Android smart-phones; laptops were suggested as a second option. However, the cost of devices and Internet access were addressed as problematic.

4.4.4.4.. Created material, portfolios; evaluation

Participants developed portfolios over the workshop (daily notes in Word). Topics to be covered, and structure:

- What I have learned today; knowledge I have acquired
- What was new for me (topics, comments)?
- What can I take with me for my teaching?
- Summary: keywords, final comments, worksheet to be attached

Most teachers were not familiar with extracting keywords from a text or presentation. Severe problems were observed in formulating short statements, e.g. summarising a lesson in their own words.

On a daily basis, two or three teachers were asked to present their work (presentations, spreadsheets, portfolio; proposals for class teaching) to the group. Presenters received immediate verbal feedback.

At the end of the workshop the participants and the course leader evaluated the developed material. The researcher graded a final evaluation of participants' development and outcomes.

14 teachers fulfilled the requirements (course attendance, portfolio, individual worksheets and presentations). A certificate for successful completion was presented in a General Assembly to

the top three teachers in front of staff and all SHS students. This should encourage teachers and students to reflect on visions of ICT integration in their studies.

4.4.5 Reflection, Summary of Findings (Cycle 1)

The workshop intended to investigate possibilities for integration of ICT in teaching. Monitoring and evaluation of the workshop provided feedback on achievements and challenges, especially the individually created portfolios contributed to a better understanding of teachers' perceptions and attitudes. The author gained deeper knowledge about the school community.

It can be argued that problems with portfolio creation could be related to the fact that English is the official language in education, but not the local language. This may be a cause for forming very short sentences and writing only short texts.

- Benefits

Teachers ambitions for a shift with ICT integration in daily practice:

Starting the research with a teacher workshop, where only interested participants had applied, was a good strategy. The procedure of selecting interested lecturers turned out to be optimal. Teachers were motivated to rethink pedagogical attempts in their daily business; they were motivated to continue with development of digital material for class teaching. Presentation of individually developed material contributed to enhanced personal skills in creating material, and in enhancing presentation skills and evaluation procedures. Participants agreed to contribute actively to strategies to improve teaching and learning practice with digital devices for the benefit of education and the life-prospects of young people.

Device availability

Data confirmed high ownership of devices for developing presentations, worksheets etc., which can support further developments. It can be assumed that it can encourage teachers to develop digital material with their own devices; more than 90% can do so without the need to use the computer lab.

- Challenges

Infrastructure and equipment in the school

The conditions in the computer lab were the most challenging issue. Frequent power outages, lack of Internet connection and insufficient maintenance of the hardware affected the workshop negatively. Software installations and updates (anti-virus, programmes) were not possible. Beyond that, the computer lab is only open for ICT class lessons (school policy). For students, it was prohibited to bring mobile phones to school and into the campus area (including dormitories).

Workshop Programme Completion

Internet for learning and teaching could not be performed to the planned extent. Main topics of the course curriculum had to be postponed, e.g. evaluation of OER with regard to local demands, upload of material to the cloud, installation of freely available software.

File sharing was mainly performed with USB drives, causing severe problems due to virus infections.

4.4.6 Revision and Future

Reflection was most helpful to recognise the need for redesign of the follow-up study, raising the question of how to progress in a more effective way.

How to cope with challenges?

- Rethink methods for accessing information, Internet (important for developing evaluation skills for OER and material on the web).
- How can locally developed material be provided without support of a learning management system (no staff available for supporting such a system)?
- How can students get access to learning material?

Based on the experiences and the need to find a strategy for coping with the infrastructural challenges, it was decided to shift the direction of the research to investigating strategies for integration of mobile learning and teamwork.

Factors that supported this decision:

- Ownership of devices in contrast to the equipment at school
- Positive perceptions of teachers to continue with content development, motivation of students in new learning attempts
- Achievements with teachers' digital skills
- Increasing interest in transforming pedagogy from teacher-directed methods toward social constructivism
- Enabling mobile learning: combining student-generated content and learning contexts;
- Innovative and active approach to new teaching strategies.

A deeper understanding of local teaching practice encouraged the author to expand the focus by extending participatory methods, incorporating students into the second cycle.

4.5 Cycle Two, 2013
Content creation for Mobile Devices

A deeper understanding of local teaching practice gained in the first workshop enabled the author to expand the focus in extended participatory design of the second workshop (Figure 4.7).

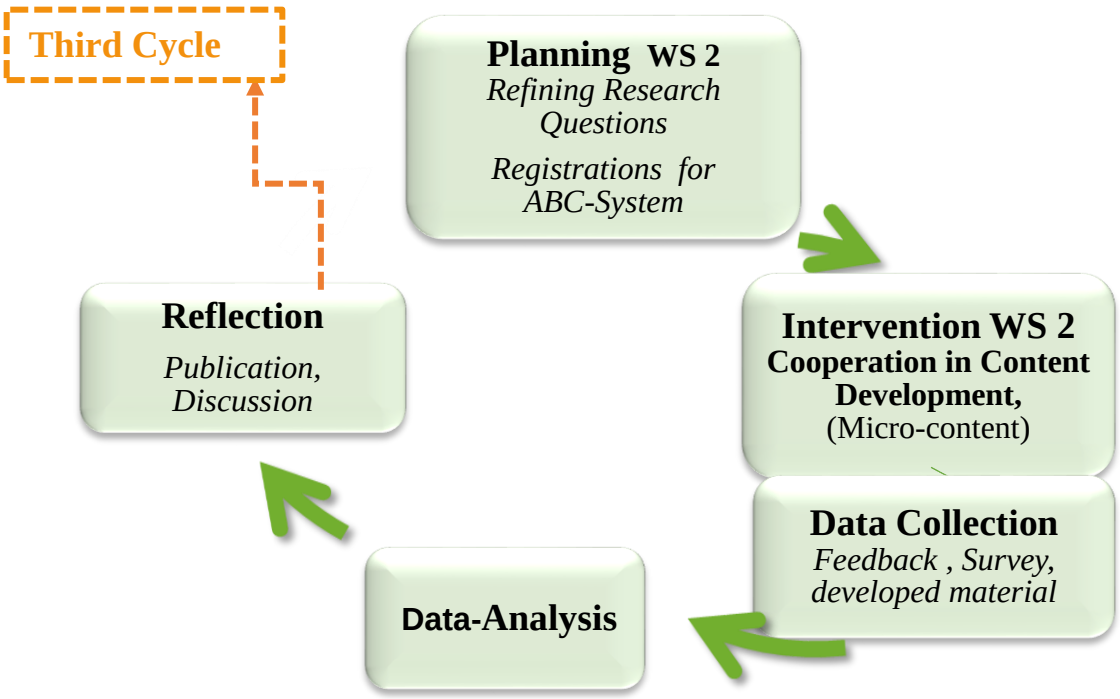


Figure 4.7 AR Cycle 2: Content development, cooperative learning

4.5.1 Planning the 2nd Workshop

Although the action research did not initially follow a clear plan, the project evolved after the first workshop. Face to face discussions with experts in the field of mobile learning during the mLearn conference in Helsinki (October 2012, with Mohamed Ally, John Traxler and Agnes Kukulska-Hulme, to name a few) were very helpful in planning the second cycle. Discussions were continued during the UNESCO Mobile Learning Week in Paris (February 2013) with experts from the World Bank, UNESCO and researchers in other African countries. These discussions provided helpful suggestions and new ideas of how to continue.

Updated research questions in the second cycle (Sub-questions, SQu):

SQu 1. How can teachers be encouraged to integrate new pedagogical attempts, including mobile learning activities, in their daily practice?

SQu 2. How can students assist in improving teaching and learning practice through integration of mobile devices for learning in a traditional school system?

Aim of the second workshop

To compensate for infrastructural challenges, the second workshop focused on how learning and teaching can be improved by integrating mobile devices. This includes preparing teachers to understand how mobile devices (laptops, mobile phones, eReaders) can be incorporated in teaching and supporting students' learning.

The focus was directed onto the development of digital content and guidelines for best practice by addressing two main goals:

1. Development of locally relevant micro-content units for online and offline access with eReaders and mobile phones, and
2. Incorporation of senior students in development of learning material.

Expected learning outcome

Teachers are able to evaluate, use and create digital learning material, e.g. micro-content (small learning units, see 2.8.2), by adjusting material available online or in books for local demands, and by integrating images, figures and graphs.

Figure 4.8 Nokia E5-00 Smartphone

Tools

20 mobile phones (Figure 4.8), second-hand Nokia E5-00 smart-phones, 256k display colours, 10 days standby, 2GB Micro-SDHC card included in box (a gift from an Austrian friend), 5 eReaders, TrekSTor E-Book Reader Pyrus mini, 4.3" Digital Ink (Figure 4.9) and a WLAN router for testing on-site were provided.

Prior to the workshop, all participants were registered in the ABC system [49] (hosted at Graz Technical University, https://ebook.tugraz.at). ABC is an online authoring tool for generation of content for teaching and learning purposes (mobile learning). E-books can be released in various formats: online, displayed within an e-book environment; mobile versions, including personal notes; as SCORM (Sharable Content Object Reference Model) packages; and downloadable offline versions, e.g. PDF, ePub. (Ebner et al, 2014b, Nagler et al., 2011)


Figure 4.9 eBook Reader Pyrus mini

[49] https://online.tugraz.at/tug_online/fdb_detail.ansicht?cvfanr=F27846&cvorgnr=&sprache=2&pNoCheck=2

4.5.2 On-site Activity, Intervention
Development of digital content, guidelines

Schedule

Two weeks of full-day teacher training, followed by one week of teamwork, in which students and teachers worked in mixed teams on curriculum topics (course lessons and guided practice).

Participants

20 teachers registered; 14 participated. After ten days, 13 students joined the workshop. A final-year student (Noah) assisted in the technical and organisational aspects. His support contributed to the success of the workshop and was very much appreciated by teachers and students. (see also section 5.8)

In the first two weeks (teachers only), the focus was on pedagogy and possibilities for integrating mobile learning. Web search strategies were investigated; micro-content (see 2.6.8) was created and later tested in teacher-student teams.

Workshop topics

- Pedagogy: evaluation of digital learning material (Open Content, OER, Simple English Wikipedia), importance of Creative Commons; possibilities for integration into class teaching. Most online material needs to be adapted to local curricula.
- Collaborative learning methods; using cloud infrastructure (Dropbox) for micro-content development, evaluation, feedback and peer review.
- Development of locally relevant digitised content for subject-teaching; micro-content units, accessible with mobile phones and eReaders (ePub, pdf format); uploading to the ABC- eBook Reader programme.
- Best practice:
- Mobile devices for learning, development of guidelines for proper use of mobile devices.
- Responsible use of mobile phones and Internet: legal and ethical aspects, safety and security policies
- Creation of link lists for self-conducted learning.
- Development of a personal digital portfolio (students were introduced to this activity).

Micro-units for specific topics of the curriculum were developed in teacher-student teams (1-2 teachers and 1-2 students, on the subject taught by the teacher). The ABC platform was used for converting of MS Word documents to ePub and pdf- formats.

In order to rethink methods of learning and teaching the following scenario was presented:

‘In five years all textbooks in Ghanaian Senior High Secondary Schools (SHSS) are provided as eBooks.’

Task: Discuss possible consequences in teams (2 or 3 participants)

a) for teaching,

b) for learning,

c) for schools

and present the outcome as a poster. (Figure 4.8)

Note: Due to a sudden power outage the posters had to be developed in handwriting.

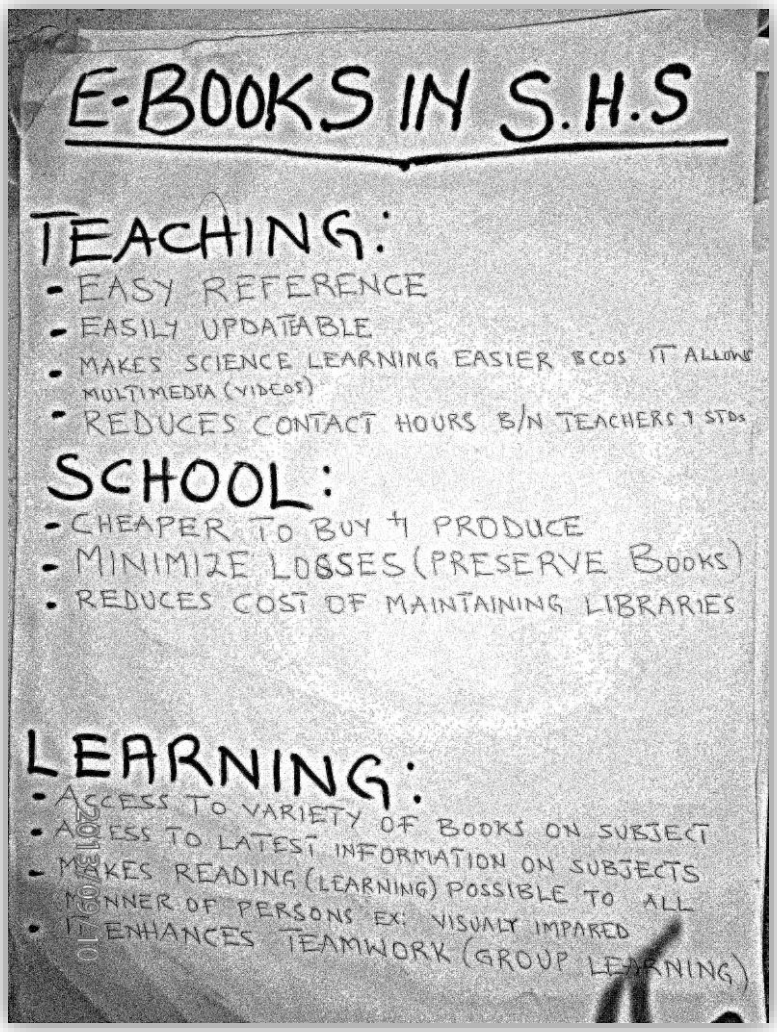


Figure 4.10 Task: eBooks, chances in Ghanaian SHS future

4.5.3 Data Collection

First-hand research was carried out in order to generate a better picture of teachers' and students' abilities for development of digital content appropriate to local needs. Data (qualitative and quantitative) were collected using observations and surveys (Table 4.6).

The surveys featured various question types, including open questions and comments.

Data Collection	*Analysis*	*Method, Material*
Observations (4.5.4.1)	qualitative	Journal notes (diary)
Post-Workshop Feedback (4.5.4.2)	qualitative, quantitative	Survey: teachers and students
Survey (4.5.4.3)	quantitative, qualitative	Online survey
Individually developed material (4.5.4.4)	qualitative	Portfolios, micro-content, posters, presentations (individual and team)

Table 4.6 Data collection, AR Cycle 2

4.5.4 Data Analysis and Interpretation (WS 2)

4.5.4.1.. Observations

Observations were conducted during the workshop hours in the computer lab and on the campus site. It was recognised that much had changed since the first workshop: More teachers from the school were open to new teaching methods; some had already experimented with presentations in class teaching; individual digital competence had increased, mainly in Internet research with private devices.

Unfortunately, there was little change in the infrastructure: frequent power outages and restricted bandwidth (Wi-Fi) were still an obstacle. This caused innumerable restarts of the computers in the lab. Uploading newly created micro-learning units to the ABC system was nearly impossible. Although a new Wi-Fi modem was installed, the connection did not supply sufficient performance for working in parallel groups.

Observations on the campus provided wider insights into the environmental situation. Key issues are summarised in Table 4.7.

Main Issues	Findings
Teacher: Internet skills	Lack of awareness of Internet safety, privacy and guidelines for best practice
Web search and evaluation	Lack of competency in information retrieval, e.g. defining search queries, evaluation of retrieved query results, saving results (e.g. images, text), copyright issues (e.g. Creative Commons).
Infrastructure	Nearly no change from the previous year.
Equipment	Many teachers used their private laptops and smartphones as a supplement to the desktop PCs in the computer lab to overcome equipment deficits.

Table 4.7 Summary of observations, 2. workshop (2013)

4.5.4.2.. Post-workshop survey, feedback

At the end of the workshop, all participants were asked to complete a questionnaire for evaluative response to concerns and perceptions of learning and teaching with mobile devices. The course feedback was composed of 13 items for students and 15 for teachers. **(**Appendix 4.7 Feedback Teachers, Appendix 4.8 Feedback Students, 2013). The survey was prepared as an online questionnaire, but due to a sudden power outage, paper copies had to be prepared for completion of the survey.

Findings:

Workshop content: Likert grades from teachers and students are displayed in Figure 4.11 (Likert grades:1 = strongly disagree; 2 = disagree; 3= agree; 4 = strongly agree; maximum=4).

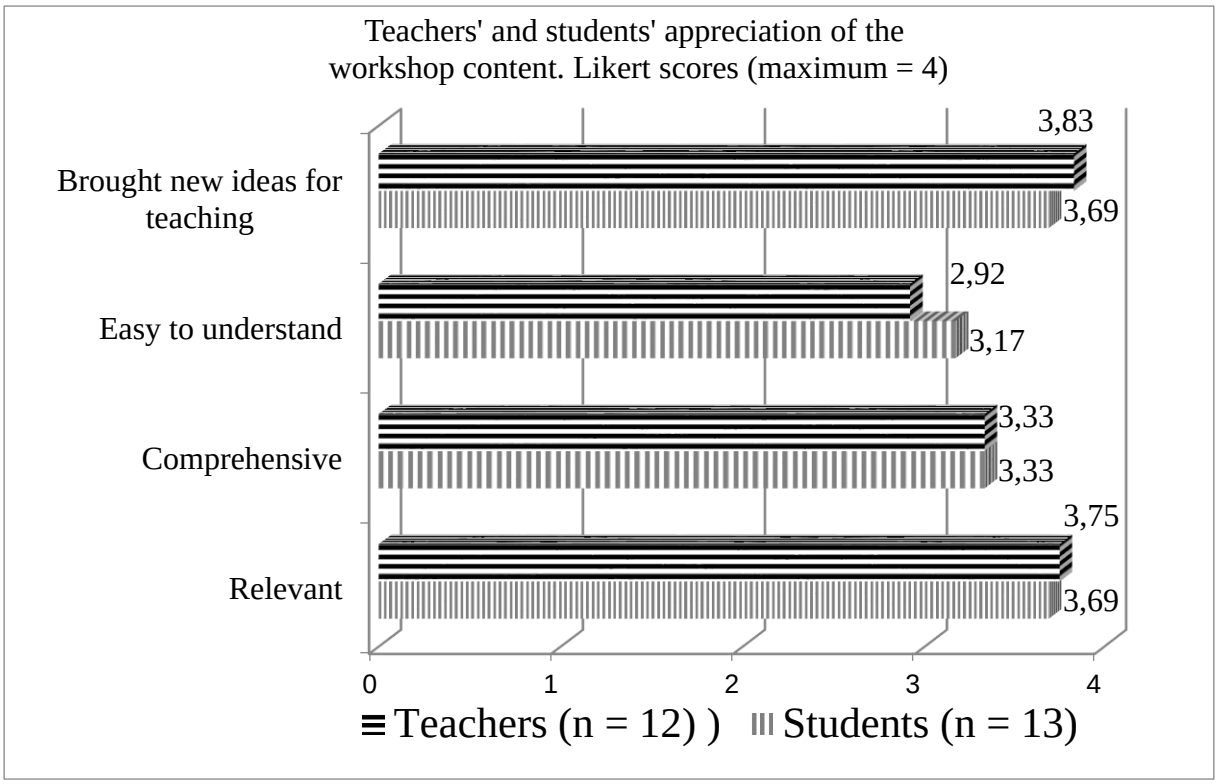


Figure 4.11 Likert scores, appreciation of the workshop content, teachers and students

The perceptions of teachers and students were quite similar, and in response to 'comprehensive' identical. Students were more likely to agree with 'easy to understand', whereas teachers were more likely to agree with 'new ideas for teaching', and that the content was 'relevant' for teachers.

Benefits, Challenges, Comments

Both groups (students and teachers) confirmed benefits for learning/teaching from the workshop; all appreciated the practical part, particularly working together in teams (teachers and students). A sample of comments in response to open questions is provided in Table 4.8 (clustered and partly in original phrasing).

Teacher (n=12)	*Student (n=13)*
Benefits	
New tasks, can enhance teaching: 'new ideas for teaching particular topics'; 'benefits teaching when integrating group work' 'interactiveness',	'learned that I can use my mobile phone for more than just for gaming'; 'realised that I can do much more with my mobile'; 'makes learning easier'; 'can get more information on my own without having to contact my

‘students will appreciate this kind of learning’	teacher’; ‘easier sharing information with friends and teachers’; reading eBooks’; ‘aids my study-plan, getting information quick’.
Challenges & Liked Least Similar answers from teachers and students: poor infrastructure and Internet connectivity, ‘poor Wi-Fi availability,’ and ‘frequent power outages’ Students are not allowed to bring mobile phones to class	
‘lack of facilities needed’. Two teachers claimed that some teachers came late or were absent for some parts of the course.	5x claims: ‘mobile devices not allowed’ ‘disruptive attention in class’, ‘rules need to be changed’; ‘challenges can only be avoided when proper rules are strictly adhere to it’
Like best’ Most important: Practical aspects are mentioned by both teachers and students	
Interactive nature of the workshop, group work; ’hands on’; ‘new methods for learning and teaching’; ‘task-oriented structure of the course’, ‘appreciated the practical part and activities’	‘creating own content and presentations’ ‘learnt how to use Internet more easily’
Free comments	
‘program should keep running’; ‘opened my eyes to new ideas of teaching’; ‘enhances teaching’; ‘teachers need regularly continued professional development’; necessary for 21st century teachers’, ‘need more of it’.	‘helps me to see a new way of learning’; ‘first time using a computer in this way’, ‘Helps sharing information with peers and teachers, most elaborative,’ ‘learnt how to structure courses to make them mobile device friendly’
Cooperation (teacher - students) This was highly appreciated by both teachers and students, everyone was encouraged to work in teams	
‘appreciated teamwork together with students;’, ‘Students are familiar with the use of computers’;	‘built new student-teacher- relationship’; got to know how teachers feel when teaching in the archaic way’, ‘learnt a lot from them and even got closer to them;’

Table 4.8 Impact of the workshop: selected items, students’ and teachers’ answers and comments in original wording.

Appreciation of using the cloud (Dropbox) for sharing material and providing handouts for download: Likert grading, teachers and students (Table 4.9).

Likert *Teacher*	Use of the cloud (max. = 4)	Likert *Student*
3.50	Supports content sharing	3.25
3.73	Provides useful information	3.67
3.58	Structure of content (organisation)	3.31

Table 4.9 Appreciation of cloud storage

Teachers were likely to use Dropbox for providing material for students. A lower appreciation of students might be due to their knowledge of different channels for sharing material (e.g. social networks, Google+).

Teachers were asked about their pedagogical/didactical knowledge for integrating mobile devices in teaching: *before* and *after* the workshop (self-assessment, Table 4.10).

Teachers knowledge/appreciation of integrating mobile devices	poor	fair	good	excellent
Before workshop	4	4	4	0
After workshop	0	0	8	4

Table 4.10 Pedagogical/didactical knowledge for integrating mobile devices in teaching:

Teachers: 'To what extent can the use of mobile devices benefit teaching and support students' learning?' (Table 4.11)

Teacher: expected benefits of mobile devices for students' learning	poor	fair	good	excellent
Before workshop	2	5	4	1
After workshop	0	1	6	5

Table 4.11 Pre /Post rating: benefit of mobile devices for teaching /learning?

Students: To what extent could the use of mobile devices benefit learning (Table 4.12)

Students: expected benefits of mobile devices for learning?	poor	fair	good	excellent
Before workshop	3	9	1	0
After workshop	0	0	4	9

Table 4.12 Student: Use of mobile devices, benefits for learning.

The outcomes shows clearly the increase in didactical knowledge of use of mobile devices for teaching and learning and agreement with expected improvement in students' outcomes. Both,

teachers' and students' knowledge about benefits of using a mobile device for teaching or learning increased remarkably during the workshop.

4.5.4.3.. Online Survey

An online survey, similar to that used in the first workshop, was prepared for teachers and students. (Appendix 4.9 Online Survey 2013)

Outcome

Not all respondents answered all items. Beyond that, in 19 cases it was not clear whether the respondent is a teacher or a student, these responses were excluded from evaluation. 61 responses were analysed (anonymously).

Demographical data: 18 teachers (six less than 30 years of age, ten between 31 and 40 years, one 49 and one 59 years old), 43 students (aged between 15 and 20 years).

Subjects taught (teachers) were Biology (2), Economics (2), English (3), Social Studies (3), Graphic Design (3), ICT (3), Mathematics (2), Leatherwork, Graphics, Physics, Business Management, Chemistry, Geography and Government.

Device ownership

Teachers' device ownership, gathered in 2012 and 2013, and students' ownership in 2013 is outlined in Table 4.13 (multiple answers possible).

	Teacher 2012		Teacher 2013		Student 2013	
Ownership of devices	n =36		n=18		n=43	
Mobile phone	*31*	*86%*	17	94%	40	93%
Computer (desktop or tower)	*20*	*56%*	9	50%	13	30%
Laptop or Netbook	*27*	*70%*	12	67%	15	35%
Tablet	*5*	*14%*	2	11%	2	5%
Digital Camera/Videorecorder	*14*	*39%*	4	22%	5	12%
Other (Kindle, iPod)	*2*	*6%*	3	17%	4	9%

Table 4.13 Responses to 'Which of these devices do you own?'

There was only a slight difference in teachers' ownership between 2012 and 2013; it should be noted that in 2013, the number of respondents was only half that in 2012. 16 teachers (89%) owned a computer or a laptop in 2013; five of them (27% of the total) owned both (PC and laptop); two of them had a tablet as well. Two teachers (11%) owned neither a PC nor a laptop or tablet in 2013.

About one third of the students confirmed owning a computer, another third a laptop; seven of them had both (PC and laptop), and two had an additional tablet. More than half of the students (22; 51%) said they owned neither a PC nor a laptop. Nearly all (92%) students owned a mobile phone; 38% had smartphones (Table 4.14).

	Teacher 2012		Teacher 2013		Students 2013	
Type of mobile phone	n=31		n=17		n=40	
Smartphone	*15*	*48%*	8	47%	15	38%
Feature-phone	*4*	*13%*	2	12%	9	23%
Common (basic) mobile phone	*12*	*39%*	7	41%	13	33%
Don't know	*0*	*0%*	0	0%	3	7%

Table 4.14 Responses to 'Which type of mobile phone do you use?'

A mobile phone with Internet access is more convenient to be used as a learning tool. (Table 4.15)

	Teacher 2012		Teacher 2013		Students 2013	
Internet Access available?	n =31		n=17		n=40	
Yes, always	*24*	*77%*	11	65%	31	77%
Yes, but only when Wi-Fi is available	*4*	*13%*	2	12%	4	10%
No, can't access the Internet	*3*	*10%*	4	24%	5	13%

Table 4.15 Responses to 'Internet access with your mobile phone?

A difference in accessibility of the Internet with mobile phones was found for teachers in September 2013. This might be due to the low number of participating teachers. When combining the samples from 2012 and 2013, and looking at the total numbers of teachers, there is no significant difference between teachers and students. 87% of the students and 85% of the teachers can access online content at least when Wi-Fi is available.

Perceptions of using a mobile phone for teaching or learning

Teachers and students' experience in using mobile devices for learning were investigated. Two teachers and six students responded as having already used 'free mobile learning content available on mobile devices', whereas 13 teachers (72%) and 25 students (58%) have not used their mobile devices for learning, but were interested to do so.

It is noteworthy that students are more open to use freely available content with their mobile devices.

Nine teachers (50%) affirmed the use of a mobile phone for teaching, research and calculations; for example, *'I download material and prepare my own notes'*. 13 teachers would like to find content for professional development on their mobile devices; only two had experienced this so far.

26 students said they use their mobile device for research; two more for reading books, and another four for scientific studies. Examples of comments: *'... normally I use it for researching and learning about current news'; 'for research and communication of ideas with colleagues'; 'asking friends questions on social networks'*.

25 students would like to find learning material on their mobile devices; six had already experienced this option. Most common sites are wikipedia.com; google.com; chemworld.com; khanacademy.com (4x); physicsclassroom.com; skoool.com; www.4shared.com; yahoo.com.

Teachers' and students' perceptions of using different types of learning material were investigated: *Would you agree that having course material available on your mobile device would be beneficial for teaching/learning?* Likert scores (5-point Likert scale, *strongly agree* to *strongly disagree*; max. = 5) are displayed in Figure 4.12.

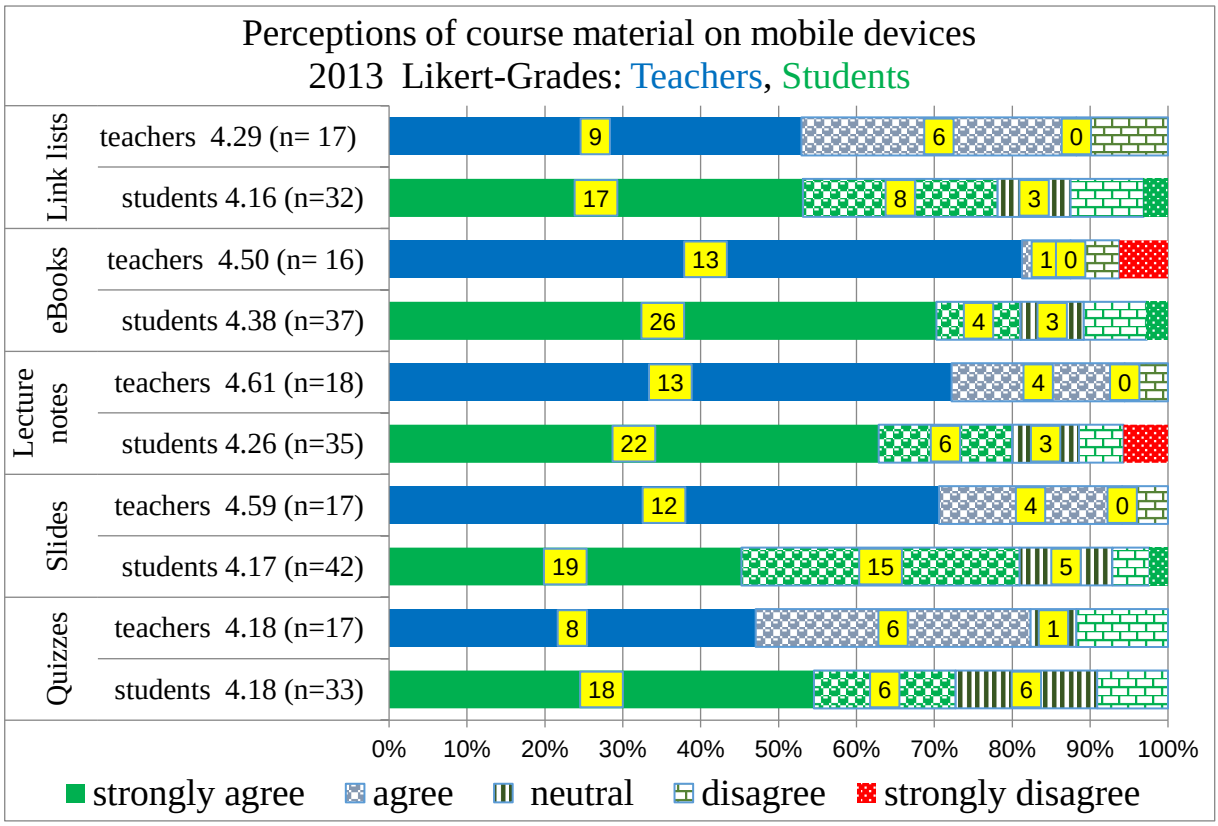


Figure 4.12 Likert scores: teachers' and students' perceptions of course material available on mobile devices.

Both teachers' perceptions (average of 4.43) as well as students' (average of 4.23) regarding different kinds of supporting material are highly appreciative. In 2012 (previous survey), teachers scored identically (average 4.4).

4.5.4.4.. Developed material, evaluation

Four external examiners (teachers from other SHS) performed the task of evaluating portfolios, guidelines and course units. Each of them approved the quality of material anonymously and provided individual comments. Evaluation of the single task was based on the criteria outlined below:

- Portfolios (individually): assessment on the quality of reports, structure, achieved learning outcome, keywords, take-home statements and summary.
- Guidelines, Best Practice Posters (teams): assessment based on completeness.
- Course units, micro-content (teams): assessment on course structure, design; micro-units - appropriateness for small screens? Readability on eBook Readers and mobile phones? Patterns of visualisation, e.g. images, graphs; oral presentation to the audience.

The assessments were finally graded together with the researcher (very poor/ acceptable/ good/ excellent). Feedback was provided to the participants individually and to the teams immediately after their presentations. Scores were calculated and handed over to the principal. The best three contributors in the single categories received an award. Eleven teachers fulfilled the requirements of participation and received a certificate, similar to those from the previous workshop; students received a similar certificate (Figure 4.13). Requirements for certificates included fulltime participation in the workshop, a digital portfolio, and contributing to the development of a course unit available on a mobile phone and eBook Reader. The headmaster presented certificates to teachers and students in the General Assembly during the opening ceremony.


Learning and Teaching with Mobile Devices
Keta Senior High Technical School, Keta, Ghana
09-27 September 2013
Certificate of Attendance
This is to certify that
Paul K. HE
has successfully completed the workshop (60 hours) on:
* Cooperative Learning and Teaching, Interactive Learning
* Creation of content for Mobile Devices, Guidelines - Best Practice
Keta, September 2013
Dr. D. K. Sedanu-Kwawu
Headmaster
Keta Senior High Technical School
Keta, Ghana
Prof. DI Margarete Grimus
Course Leader
University of Technology
Graz, Austria

Figure 4.13 Certificate for Workshop participation.

Topics of micro-content units (subject: topic):

ICT: Classification of Computer Hardware; Social Studies: Adolescence, Pregnancy, Adolescence, Chasity; Physics: Atomic Bonds, Projectiles; Atom Physics; English: English Nouns; Business Studies: Law of Agency; Graphic Design: Elements of Design; Economics: Demand; Mathematics: Set Theory; Chemistry: Interatomic Bonds.

Examples of course units

In the screenshots below, course units for eBook Readers are displayed. Figure 4.14 represents the learning objectives on the topic ‘Atom Physics’, and Figure 4.15 the course structure of ‘Basics of Atom Physics’.

Figure 4.16 illustrates the structure of a course unit (Unit 5, New Technology) on the topic ‘Classification of Computer Hardware’ and the associated task. On the right frame the structure of the course is displayed.

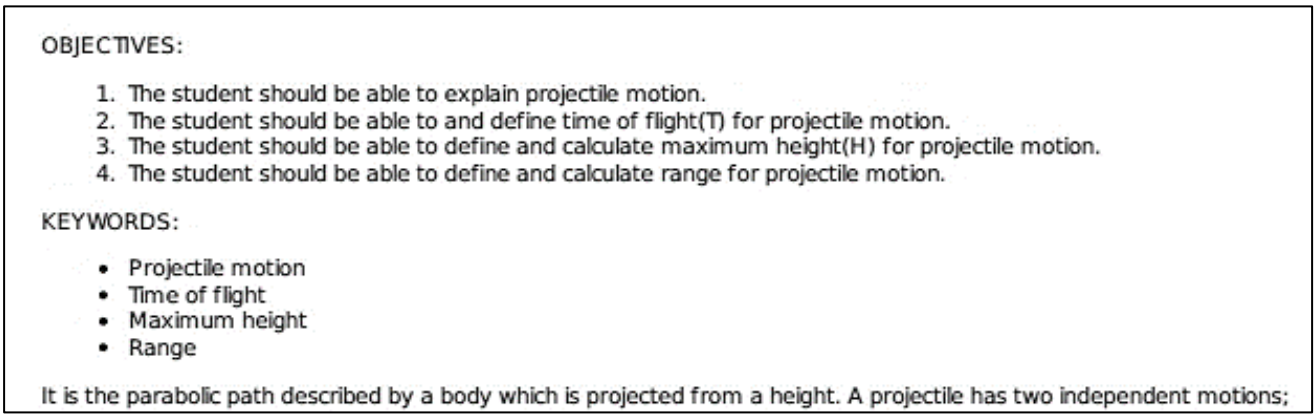


Figure 4.15 Basics of Physics, Learning objectives for the unit Projectiles (display: eBook representation)

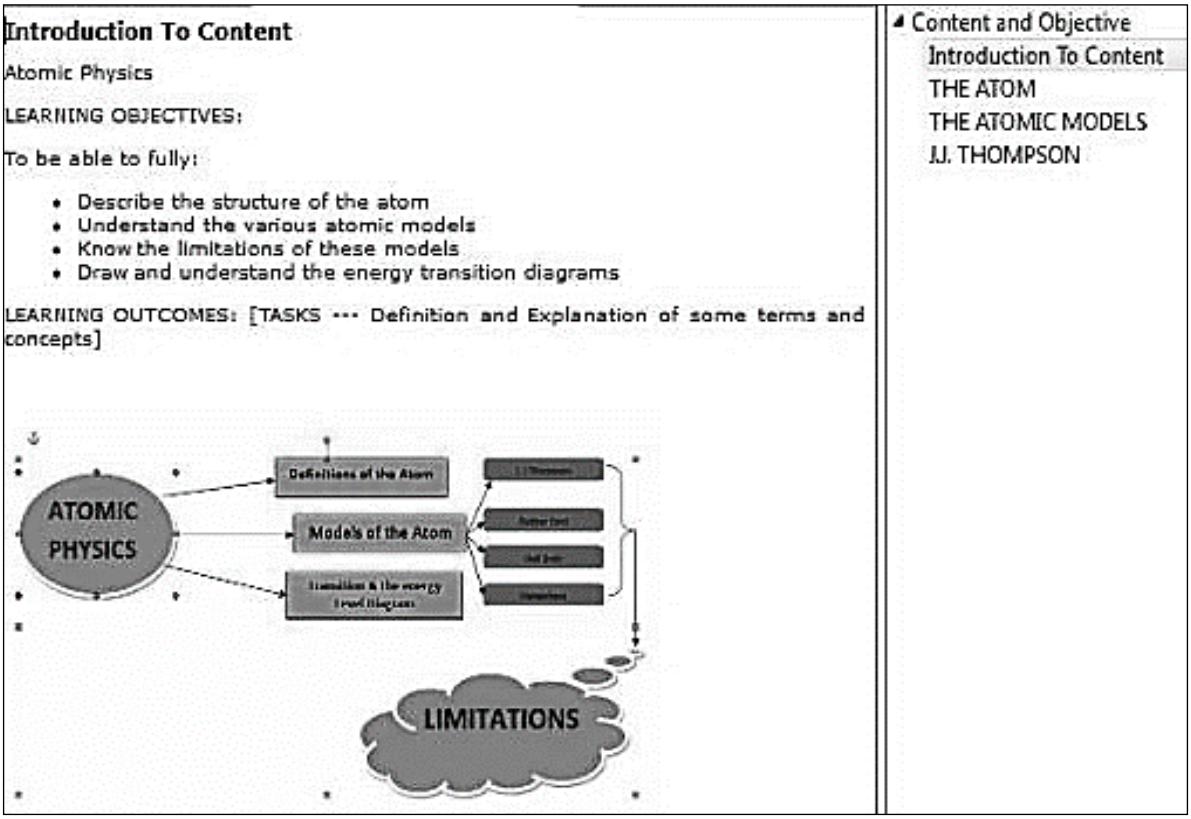


Figure 4.14 Basics of Atom Physics, course structure (display: eBook representation)

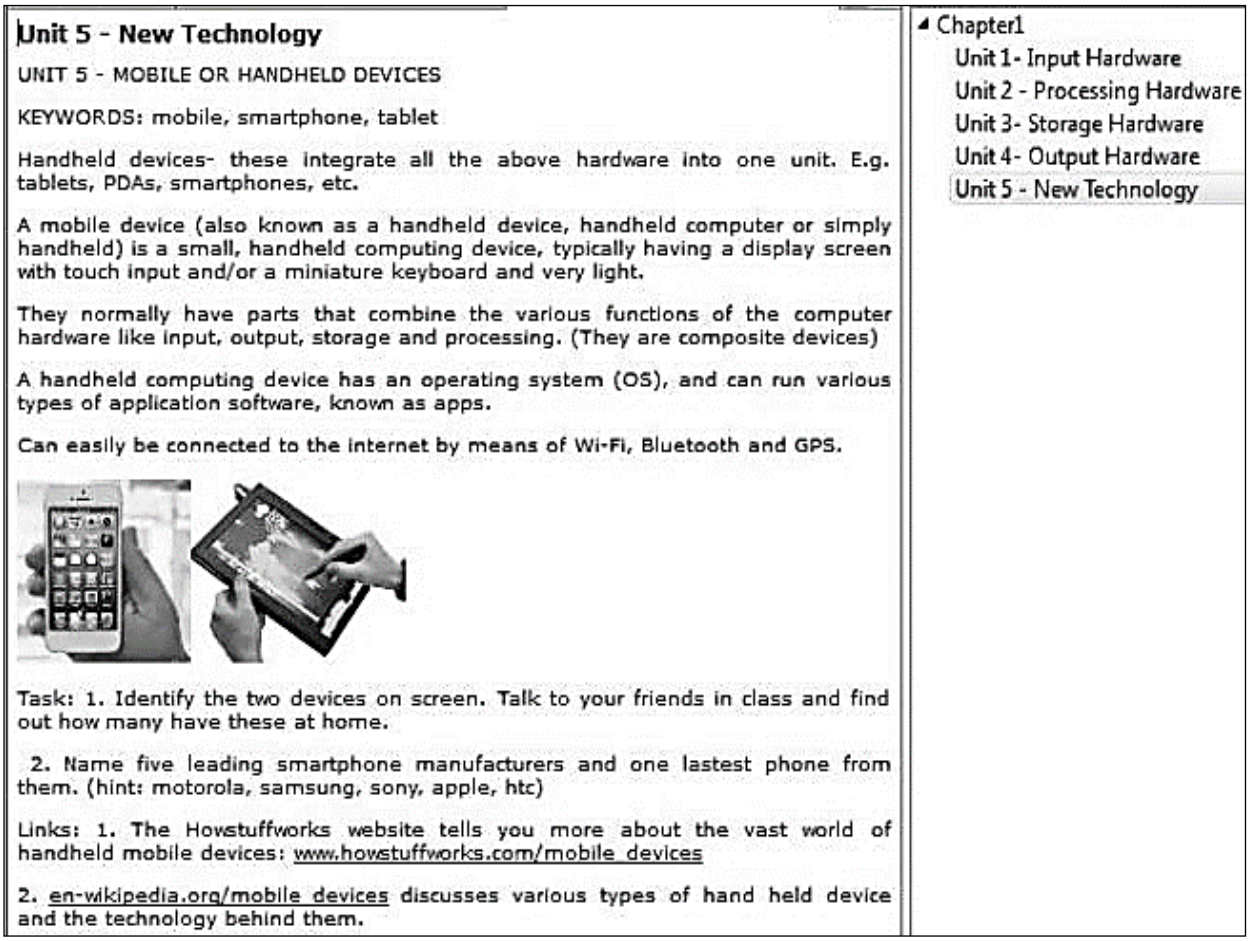


Figure 4.16 New Technology, classification of computer hardware

4.5.5 Reflection, Summary of Findings (Cycle 2)

Teachers' perceptions of using mobile devices for learning purposes are positive. A good perception of digital material available on mobile devices (e.g. link lists, eBook-readable material and lecture notes) was recognised (average Likert score of 4.4).

Teachers agree very positively with 'investing personal time for learning to use and install software that could make resources for teaching available on a mobile devices' (Likert score 4.55), and 'using free mobile content for professional development' (Likert score 4.5).

4.5.5.1.. Benefits

Teacher-student cooperation

Appropriate pedagogical support is based on understanding of students' mobile use habits and needs. Working together to create content and presentations was a new experience for teachers and students. Teachers experienced new forms of structuring and presenting curriculum topics, and students contributed with specific interest in searching for actual supplements, visualisation and layout.

Teachers' ambitions

Teachers were open-minded and tried out new didactical approaches by creating content for mobile devices. The participants were encouraged to move beyond transmissive towards more constructivist pedagogies (see 2.7.3, Learning Theories, and 2.4.4 Teachers roles). A positive mind-set helps to spread new forms of pedagogical practice and can lead to more interest among staff.

Device ownership

Although ownership of mobile phones of teachers and students was nearly equal, a considerable disparity in ownership of computers, laptops or notebooks was found. Nearly ninety percent of the responding teachers owned a PC or laptop. This makes it possible for teachers to develop learning material independently, with no need for using the computer-lab, while most of the students can access material with mobile phones (mainly phones without touchscreens).

Guidelines

Developing guidelines in teacher-student cooperation is extremely important.

In the opening ceremony of the new term the headmaster reported to students and teachers about new trends coming up in education in the school, and pointed out that this could help with becoming more critical thinkers. He continued with referring to new didactical methods and benefits from integrating mobile devices in learning and teaching. Finally, he proposed a reform of guidelines for use of mobile devices (mobile phones and eBooks) at school.

4.5.5.2.. Challenges

Severe problems with electricity and Internet connectivity continued. When web activities and content development in the computer lab are integrated, great flexibility in lesson planning is required. It is necessary to be prepared for switching immediately to an activity without computer use when a power shutoff occurs.

Using the ABC platform (online-system for conversion of micro-content units into eBooks, see 4.5.1) turned out to be an inappropriate tool in a developing country, because online conversion of text and images to the ePub format is an inappropriate solution.

Only basic experience in web search and web content evaluation was observed with both students and teachers. Due to difficulties in expressing specific learning requirements with keywords, the search results were limited.

Discussions during meetings with the school principal and teachers from other schools provided a deeper insight into environmental and cultural aspects. Unfortunately, due to elections resulting in changes at the Ministry of Education, no meeting with the authority could be arranged.

4.5.6 Revision and Future

Reflection on results of the survey had a critical impact on possible interventions in planning the activities for the third workshop.

Most important: how to cope with challenges?

- Mobile devices allow access to content even during power outages, which is a perfect solution for coping with the challenging power situation. However, mobile technology should be used only if it can support student learning and enhance the curriculum during learning experiences.
- Locally installed software for compilation of learning units to ePub and mobile formats is necessary.
- Testing network solutions in order to improve connectivity should be a topic in the future.
- Guideline-creation should be extended in more depth for use of mobile phones.

Improved understanding of local challenges and ownership of mobile phones reinforced the decision to increased use of mobile devices in the follow-up cycle.

The use of action research encouraged the author to adjust and refine the process by addressing user-generated content with respect to STEM education (Science, Technology, Engineering, and Mathematics).

Effective information retrieval strategies should be addressed. Because Google was the commonly used search engine, a different search engine (Yahoo) and Wikipedia should be an alternative issue for research options in the next workshop.

4.6 Cycle Three, 2014
Mobile Learning and STEM

The focus of this workshop (Figure 4.17) addressed three main issues, including extended participatory activities:

- STEM (Science, Technology, Engineering, Mathematics) ,
- Development of micro-learning units for eBook Readers and mobile phones in teacher-student teams (adaption to local demands, including visual adaptions, legal aspects e.g. Creative Commons).
- Evaluating the advantages of using Simple English Wikipedia with a vision of possible contribution to this open source in the future.
- Dissemination of knowledge achieved (mobile learning).

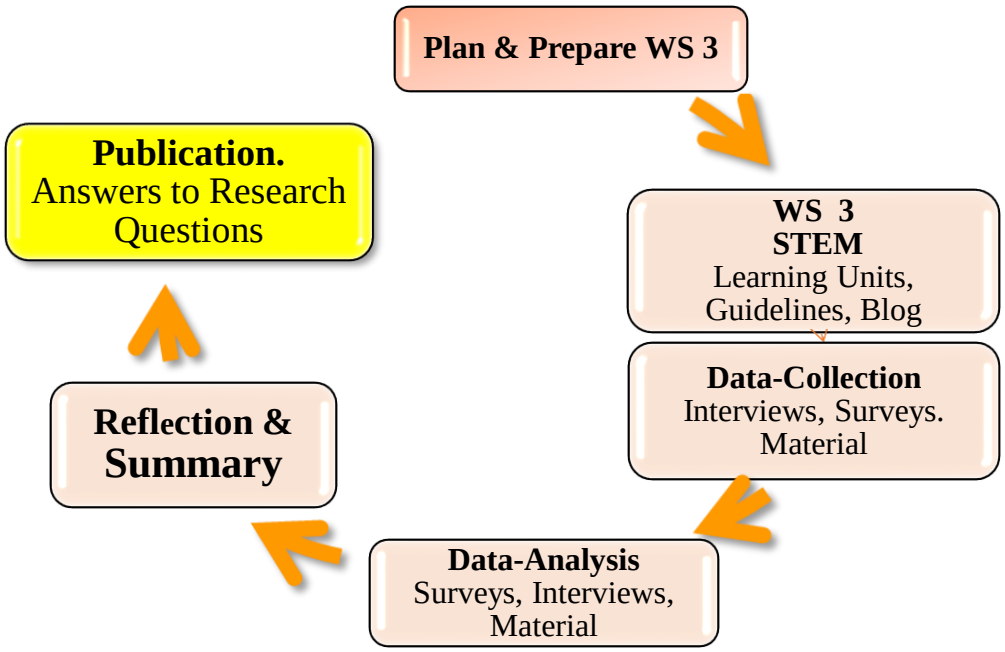


Figure 4.17 AR Cycle 3: STEM, Guidelines for use of mobile phones, Blog-development

Planning the 3rd Workshop

Reflection of shortcomings and lessons learned were discussed with colleagues from ICT4D.at. Their experience comes from projects in ICT and education in The Gambia, Mozambique, Tanzania and Ghana. Discussions with experts in the field of mobile learning were continued online and at international conferences (IADIS Madrid, 2014; UNESCO Mobile Learning Week, Paris, 2014) in order to determine new aspects for the final cycle.

A proposal for the third workshop was submitted to the principal of the school (Appendix 4.22 Proposal for the workshop in 2014).

Teacher-student cooperation was found in the previous workshop to be an excellent solution for launching STEM topics in addition to continuing with content development for subject teaching. STEM topics were addressed to shape new ideas for task generation.

The cooperation of two generations (teachers, students) encouraged the author to invite an Austrian student from the Vienna University of Technology, who is skilled and up-to-date in network technology and programming. The incorporation of the co-tutor was intended to encourage local students to discuss local, youth-relevant issues with a person closer to their age. It was expected that these visions might inspire STEM activities. His support in connectivity and server issues was also very helpful.

Aim of the Workshop

The aim of the workshop was to determine teachers' and students' perceptions and attitudes towards using mobile phones and eReaders for formal and informal learning.

Updated research questions

SQ4: How can teacher-student collaboration stimulate new educational practice and support development of locally relevant content?

SQ5: How can mobile devices encourage STEM activities and trigger creativity in new designs of task generating?

Expected learning outcomes

To overcome the challenges of poor Internet connectivity, the workshop focused on intensifying attempts for learning with the use of mobile phones.

- Student-teacher teams are competent to develop material and STEM-projects, based on interest in the subject and sharing ideas to be included in learning chunks available for mobile devices.
- Creation of micro-content with PCs and laptops; testing the material with mobile phones and eReaders.
- Conduct short interviews (teachers, students) with colleagues,
  learn to transcribe audio and video sequences into readable reports;
  reflect on the topic of mobile learning with peers.

4.6.1 On-site Activity: STEM Learning, Content Development, Mobile Learning

Schedule

The third workshop was scheduled for three weeks during school time in June 2014. Because teachers and students attended their classes as usual, course time was divided into two sessions: two hours prior to school (6:00 - 8:00) and three hours in the late afternoon (17:00 - 20:00, open-ended) and, whenever appropriate, additional guided practice.

The aim was to strengthen efforts in education for 21st century citizenship with cooperative learning methods.

Participants

10 teachers and 20 students cooperated in development of subject-related micro-content units. Subjects taught by the teacher participants were ICT, Physics, Biology, Economics, Woodwork, Weaving and English Language. The KETASCO-student (Noah) who assisted in the previous workshop had finished school and continued with assisting in logistics and technical affairs in cooperation with the Austrian co-tutor.

Workshop topics

The workshop focused on exploring how mobile devices can be effectively incorporated into learning to support students' personal development and launching STEM activities. STEM issues are closely related with the use of mobile devices for research for learning in Physics, Chemistry, Science, Computer Science and Mathematics.

- Development of micro-learning units on topics in the Ghanaian curriculum, (structure, learning outcome, assessments; ePub format), peer-evaluation, testing.
- Learning material adapted for mobile phones and eReaders: Aspects for evaluation, ethics and culture in mobile learning, copyright and Creative Commons.
- STEM activities, pedagogy, cooperative learning.
- Web search for retrieving material in order to enrich the content of a personal digital portfolio.
- Guidelines: Adaption for the school, teachers, students, including necessities for allowing mobile phones; creation of posters (meaningfulness, significance and layout)
- Social networks, blogging (opportunities, challenges)
- Creation of the blog *ketascomobile* for posting on-going and future activities.
- Link lists for self-conducted learning (selection and validation, ethics and culture).

STEM activities incorporate multiple areas of STEM disciplines through hands-on and problem-based learning. Integrative STEM education is defined as 'technological / engineering design-based learning approaches that intentionally integrate the concepts and practices of science or mathematics education, with the concepts and practices of technology or engineering education. Integrative STEM education may be enhanced through further integration with other subjects, such as language arts, social studies, art…'.(Sanders 2012, citing Sanders &Wells, 2006).

4.6.2 Data-Collection, Data Analysis

An overview of the collected samples is displayed in Table 4.16 below and for analyses in Figure 4.18

Collection/Sample	*Analysis*	*Method/Source*
Observations, Task- Examples 4.6.3.	qualitative	STEM activities and content development (teamwork): development of micro-content (task-observation), rough notes
Online Survey 4.6.4	quantitative	Questionnaire
Post-Workshop Reflection, Feedback 4.6.5	qualitative quantitative	Teachers and students feedback in longhand Presentations: Future - The way forward
Interviews 4.6.6	qualitative	Semi-structured, video/audio recorded, Perceptions of mobile learning, use of mobile phones for learning
Material created 4.6.7	qualitative	Portfolios, presentations (individual), learning units (10 teams). Guideline- posters,

Table 4.16 Data Collection, AR Cycle 3

4.6.3 Observations

Observations were carried out and discussed in cooperation with the tutor-assistant on teachers' and students' activities, skills and attitudes; for example, how they cooperated in sharing computers and mobile devices in the computer lab and on campus, or about their experiences with eReaders and mobile phones.

It was observed that personal mobile phones were used for immediate research after school on the campus despite the prohibition, which is a legal issue.

Examples of different tasks are described in more detail below.

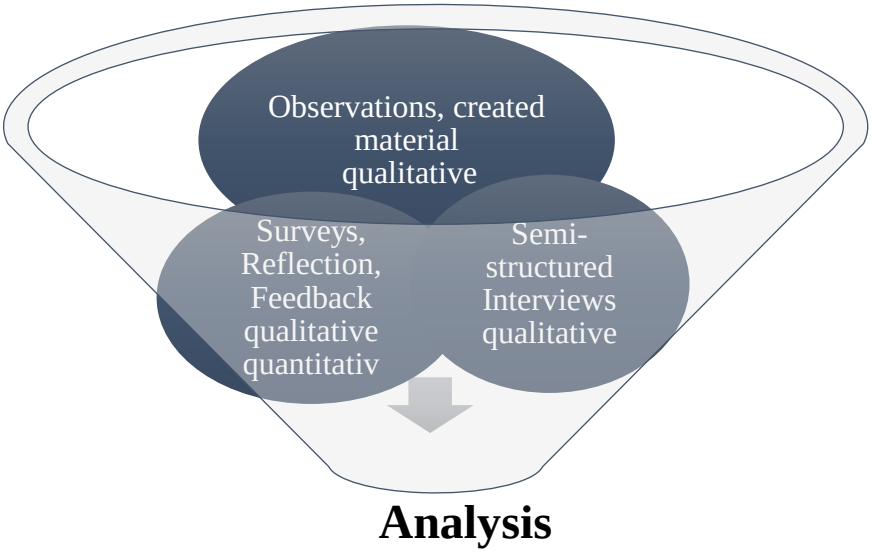


Figure 4.18 Components of Analysis

Task-Examples

Students developed a poster after their first week of participation. (Appendix 4.10 1st week poster, student)

- Initial task for launching STEM activities

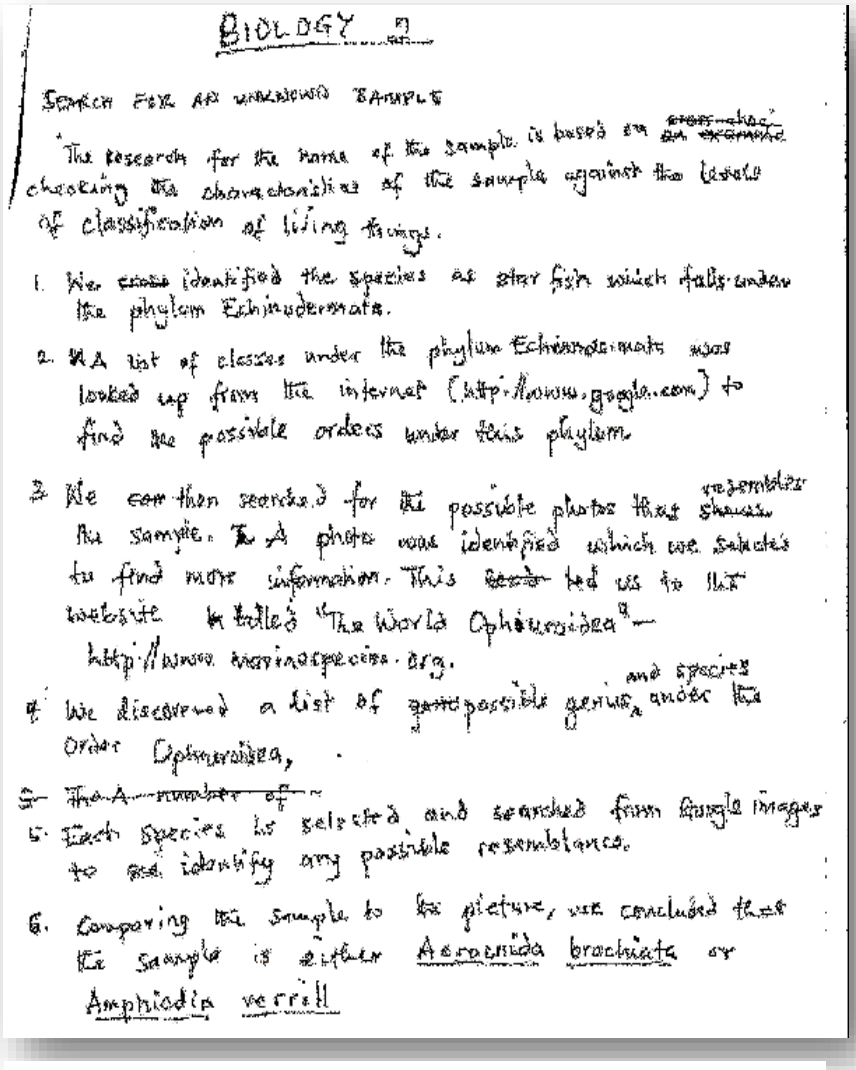
Rare items, such as a small hardware components of a computer (Engineering, Technology), or sand dollars (Figure 4.19) and skeletons of rarely spotted sea creatures were handed over to a team (Science, Biology). The tasks were carried out in two competing cross-disciplinary teams on the same topic. . Although all objects were collected by the author nearby, neither teachers nor students could initially identify the specific item.

Figure 4.19 Sand dollar (Biology)

Instructions for teamwork included: Identify and classify the object within a higher-level structure; dimensions, investigate origin, usability, etc.

Activities: describe functionality (chemical reactions), use of measurements, Internet research, calculations, if adequate

Research was documented in text and visualised (sketches, photos, videos); the documentation was presented to the group for feedback. Students and teachers assisted each other in search-strategies, proposing ideas for examining similar objects. A draft of a search documentation is displayed in Figure 4.20 (Appendix 4.11, Search Strategy, draft)



BIOLOGY 7

Search for an unknown sample

The research for the name of the sample is based on ~~an example~~ checking the characteristics of the sample against the levels of classification of living things.

1. We ~~were~~ identified the species as star fish which falls under the phylum Echinodermata.
2. A list of classes under the phylum Echinodermata was looked up from the internet (http://www.google.com) to find the possible orders under this phylum.
3. We ~~can~~ then searched for the possible photos that resembles the sample. A photo was identified which we selected to find more information. This ~~lead~~ led us to the website ~~in~~ titled "The World Ophiuroidea" — http://www.marinespecies.org.
4. We discovered a list of ~~genus~~ possible genus and species under the Order Ophiuroidea,
5. ~~The A number of~~
6. Each species is selected and searched from Google images to see identify any possible resemblances.
7. Comparing the sample to the picture, we concluded that the sample is either Aeroxenida brachiata or Amphiodia verrill

Figure 4.20 Documentation of the research, topic sand dollars.

Findings

Two pedagogical issues turned out to be a novelty:

- Active competition in teams, and
- Presenting the outcome in teams to the auditorium.

This kind of research, where students could go out and search for similar items and take photos, was a new experience. The outcome (documentation and presentation) encouraged the teams to proceed with similar tasks in in the future (see research follow-up, section 5.8).

- Search Strategies

To become acquainted with the fundamentals of web credibility testing, search procedures were performed in teams, using different devices (PCs, laptops and Nokia E5-00 smartphones). It was suggested to use mobile phones additionally for web search, because nearly all teachers and students own – or have access to – a mobile phone and mobile Internet. This facilitated overcoming the challenges in infrastructure.

Research on the topic of Ghana

Teams were encouraged to investigate information retrieval by searching for material via Wikipedia. Performing a search on the keyword 'Ghana' via Google and different sections of Wikipedia resulted in a wide variation of result quality, volume and content. Teams who had researched with different devices and search engines discussed their results. Teachers helped students in the formulation of requests (correct English).

Findings

Students were very eager to try out different search paths by using different web browsers; they preferred Yahoo for search with mobile phones.

It takes time to get familiar with searching specific sections of Wikipedia by category. Wikipedia articles include a history of changes, which allows for checking the accuracy of Wikipedia content. Most articles in Wikipedia provide links to other sources.
At the time of writing the access to Wikipedia (WIKIPEDI ZERO) is free in Ghana, no provider-cost for Internet connection are charged.

Yahoo provides access for searching within Wikipedia. In case of searching via Google, many commercial sites came up; most of them were not helpful in education, rather just filling small screens with non-essential content. It was recognised that search via Wikipedia provides valuable information; however, results on Ghana[50], found via Simple English Wikipedia, were very limited. Wikipedia Science as an entry portal [51] for research on science topics was found

[50] http://en.wikipedia.org/wiki/Ghana

[51] http://en.wikipedia.org/wiki/Portal:Science/Categories_and_Main_topics

to be very useful, as was Wikisource [52], a library of free texts, novels, essays, historical documents, poems, letters etc.

WikiBooks [53] offers material on different subjects and topics. This section was highly appreciated, particularly by female students, who were 'hungry' to find something to read in their leisure time and evenings. Students downloaded a lot of literature to the eBook Readers and enjoyed digital reading, because it is difficult for them to get hold of printed literature, due to costs and availability.

Wikismedia [54] provides images, sounds, and videos, mainly Creative Commons (CC) licensed, and recognised as a proper source for micro-content.

Simple English Wikipedia [55] was recommended as a first choice for search with laptops or computers. Finally, some students were encouraged to find out how they could contribute to Wikipedia on their own.

Content for mobile phones

Students' downloaded material retrieved from Wikipedia via laptop or PC, converted it into pdf and ePub formats, and finally saved material on their mobile phones.

Some students searched for additional useful features (apps), installed them on the phones (Figures 4.21 and 4.22), and explained how to handle these apps to their peers.

Figure 4.22 Dictionary, explanation of expressions

Figure 4.21 Apps on Nokia E5-00 phones

[52] https://en.wikisource.org/wiki/Main_Page.

[53] http://en.wikibooks.org/wiki/Main_Page Wikimedia Commons

[54] http://en.wikibooks.org/wiki/Main_Page Wikimedia Commons

[55] http://simple.wikipedia.org/wiki/Main_Page

Guidelines – Competition in development of a proper version for Best Practice

Initially, students and teachers developed guidelines separately. Thereafter extended guidelines for best practice in using mobile phones were developed in teacher-student teams, sharing ideas about usefulness and appropriateness, and combined in a final version.

First drafts were printed and pinned to the wall (names blacked out). Each competing team received three (immediate developed) simple stickers with 1, 2 or 3 stars for scoring the quality of the guidelines.

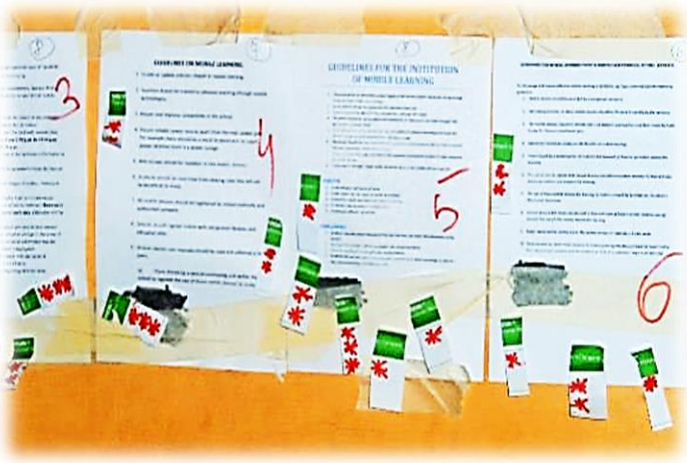
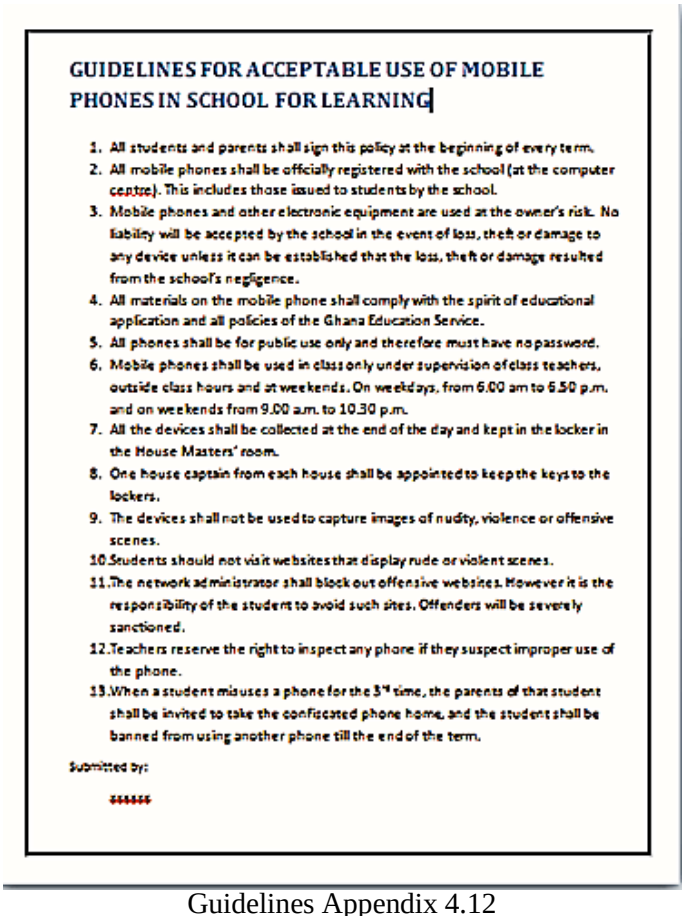


Figure 4.26 Best Practice Guidelines, rating

Figure 4.25 Discussions for rating the proposals



GUIDELINES FOR ACCEPTABLE USE OF MOBILE PHONES IN SCHOOL FOR LEARNING

1. All students and parents shall sign this policy at the beginning of every term.
2. All mobile phones shall be officially registered with the school (at the computer centre). This includes those issued to students by the school.
3. Mobile phones and other electronic equipment are used at the owner's risk. No liability will be accepted by the school in the event of loss, theft or damage to any device unless it can be established that the loss, theft or damage resulted from the school's negligence.
4. All materials on the mobile phone shall comply with the spirit of educational application and all policies of the Ghana Education Service.
5. All phones shall be for public use only and therefore must have no password.
6. Mobile phones shall be used in class only under supervision of class teachers, outside class hours and at weekends. On weekdays, from 6.00 am to 6.50 p.m. and on weekends from 9.00 a.m. to 10.30 p.m.
7. All the devices shall be collected at the end of the day and kept in the locker in the House Masters' room.
8. One house captain from each house shall be appointed to keep the keys to the lockers.
9. The devices shall not be used to capture images of nudity, violence or offensive scenes.
10. Students should not visit websites that display rude or violent scenes.
11. The network administrator shall block out offensive websites. However it is the responsibility of the student to avoid such sites. Offenders will be severely sanctioned.
12. Teachers reserve the right to inspect any phone if they suspect improper use of the phone.
13. When a student misuses a phone for the 3rd time, the parents of that student shall be invited to take the confiscated phone home, and the student shall be banned from using another phone till the end of the term.

Submitted by:

******

Guidelines Appendix 4.12

Guidelines Appendix 4.13

The proposals were discussed; qualifier-stickers were attached in order of the rankings of the guidelines, in advance of a final evaluation by an external team (Figures 4.25, 4.26).

Finally, posters with guidelines for the school were created. Poster layout was to be designed creatively to encourage acceptance by everybody (Figures 4.23 and 4.24).

Findings

Different aspects of Best Practice for using mobile phones in class were discussed, leading to deeper insights into various problems faced by teachers and students.

Development of micro- learning units

Development of micro-content for use on mobile phones and other devices was continued in more depth. Teachers were requested to propose topics from the curriculum linked to STEM interventions and matching criteria for mobile learning affordances. Each teacher drafted fundamental ideas on a poster: teaching subject, topic, keywords, and the aim of the task. Teachers explained details to students interested in a particular topic. Finally, cross-disciplinary teams were formed and presented suggestions on tasks, e.g. expected learning outcomes, key-statements, in order to get feedback.

Research on the topic included short excursions, taking photos, collecting and sharing ideas. The research was documented with mobile phones and texting. Finally, learning units were developed in the computer lab.

Figure 4.27 Testing learning units with an eBook Reader

The structure of a unit included the following:

Topic, learning outcome (definition), content, assessment and summary

The learning units were uploaded to the cloud. Other cross-disciplinary teams downloaded, evaluated, and commented on the drafts. Based on the feedback, the developers redesigned the material.

CALIBRE software, a tool for conversion to ePub format, was locally installed in order to avoid problems with Internet connectivity. The units were converted in formats for access with mobile devices and uploaded to phones and eBook Readers for testing. (Figure 4.27)

Finally, the material was saved on computers in the library, in the ICT lab and in the cloud. This allows easy update of the units. The units are available in doc, pdf and ePub formats.

Topics and subjects of learning units:

Demand and Supply (Economics); The 12-Point Colour Wheel (Art); Ecology-Systems of Classification (Biology, Figure 26); Networking of Computers (ICT, Figure 4.27); Resistors (Physics); Verb Agreement (English); Social Networking (ICT); Textiles (Weaving, Figure 4.28); Non-Wood Materials (Woodwork); Classification of Organism (Biology).

Examples of micro-content for eReaders are displayed in Figures 4.28, and 4.29.

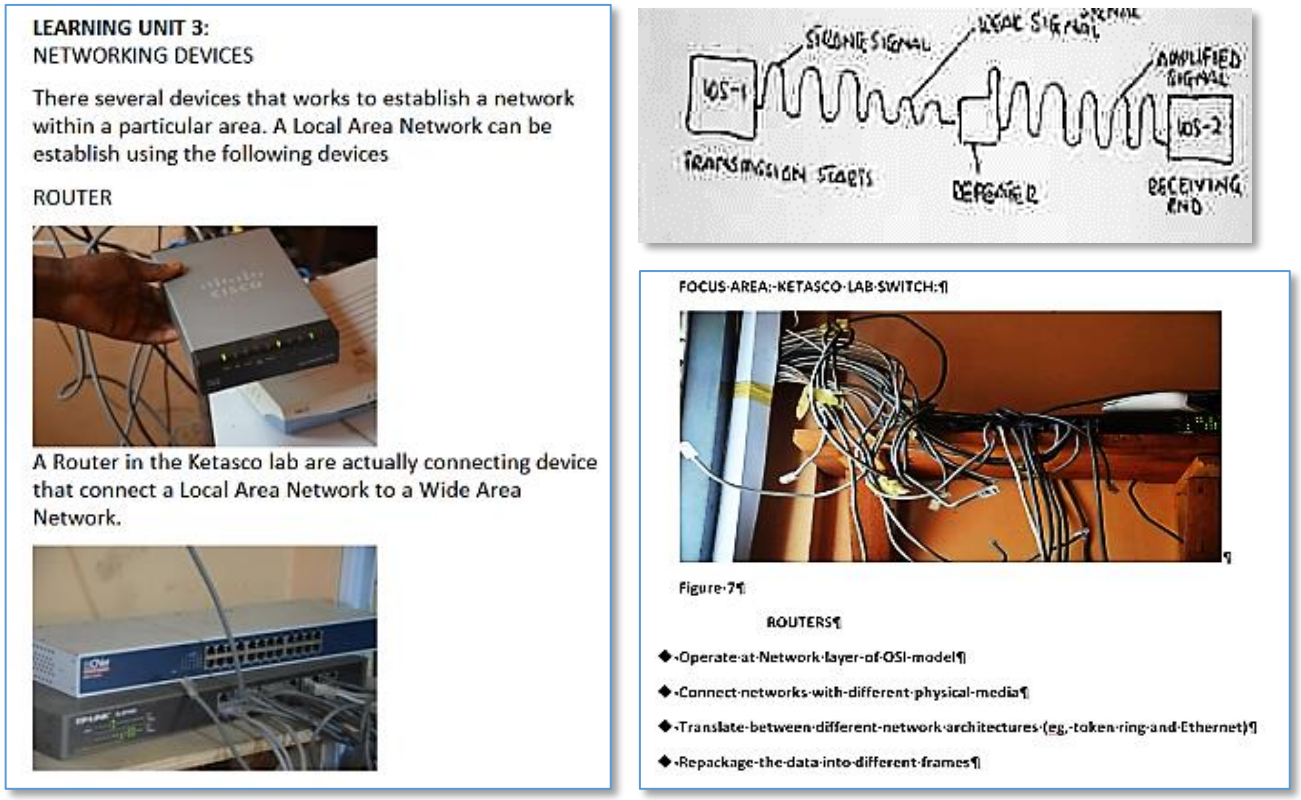


Figure 4.28 Computer Networks (ePub format)

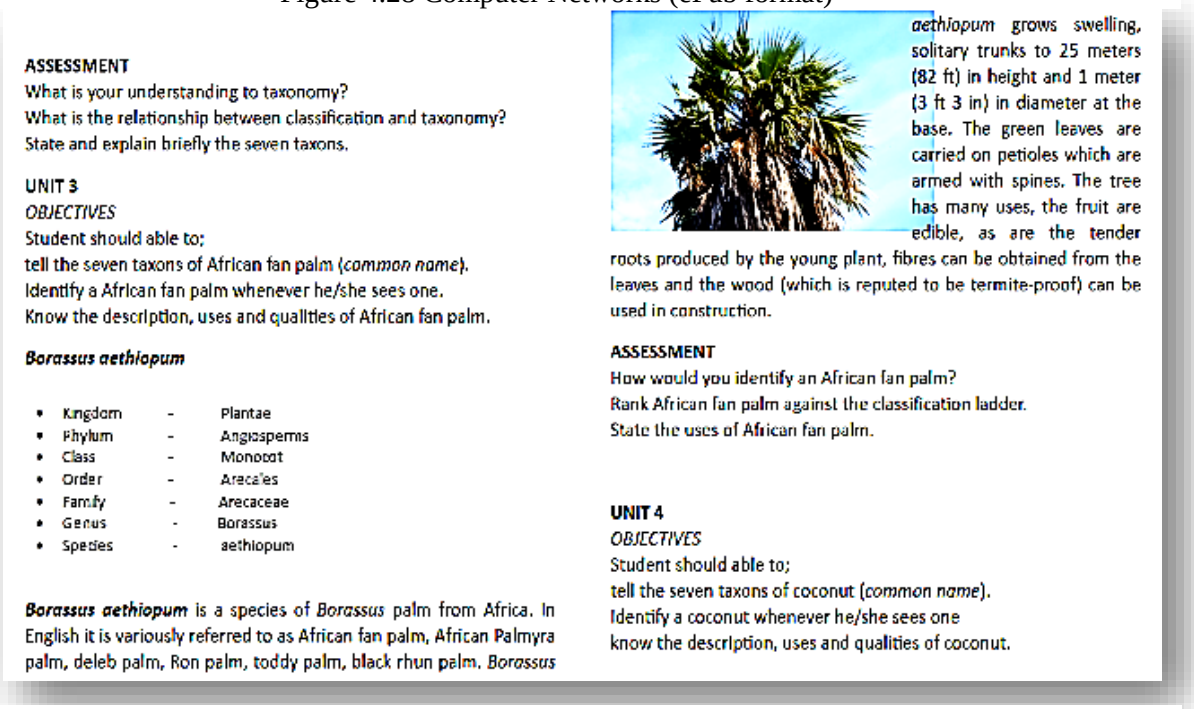


Figure 4.29 Micro-content on the subject Biology, Taxonomy, assessment (ePub-format)

Findings

When sudden power outages and a broken Internet connection did not allow continuation of work in the lab, teachers began to think about new ideas for research work. They learned to immediately switch to research activities by using mobile phones, addressing outside tasks related to the topic they were actually working on. They formulated tasks for conducting audio and video-recorded interviews and taking photos, adding value to the actual topic, and for presenting additional visual or audio material later in class:

A summary of observations is displayed in Table 4.17.

Main Issues	*Findings*
Search Literacy	Teamwork was very effective in comparing search strategies and summarising recommendations for research.
STEM and Learning units for mobile devices	Students and teachers together produced creative and well thought out material. Topics were defined by teachers. However, within three weeks it was not possible to provide a meaningful evaluation of sustainable developments in STEM activities.
Infrastructure/network	The assistance of the Austrian IT student was successful. Although the power outages could not be solved, network problems could be minimised; updates and new programmes were installed.
Equipment	The use of eBook Readers and smartphones in addition to the PCs in the lab and teacher-owned laptops provided –together with the above-mentioned network performance – better conditions than in the previous workshops.
Because of the sudden blackouts, it was necessary to develop drafts in longhand. Drafting by hand turned out to be a proper solution, as sometimes this provides better meaning than digital texting (Mueller & Oppenheimer, 2014).	

Table 4.17 Summary: issues and findings of observations

4.6.4 Online Survey

The online survey included similar items to the previous surveys (16 items for teachers, 17 for students). Teachers preferred to conduct the survey in the computer lab; however, a long-lasting power outage resulted in a low response rate, with only seven teachers responding. All teachers owned a smartphone and can access mobile Internet. Four teachers confirmed ownership of a

laptop, two of a PC and one of a tablet. Six teachers use a mobile phone at school. Teachers preferred phone calls followed by text messaging.

Outcome students

From a total of seventy-one student-respondents, only 51 completed the survey.

Sex: 41 male; 10 female. *Age*: eight were younger than 16 years of age; 28 between 16 and 18 years; 12 between 18 and 20 years and 3 were older than 20 years.

Ownership and use of devices

All students owned a mobile phone; in 35 cases (69%), they owned a smartphone.

Eighteen students (35%) responded with additional ownership of either a laptop or PC; 12 (24%) owned both (PC and laptop) and four of them owned an additional tablet. In contrast, 21 (41%) responded that they did not own any of these devices. They stated that whenever they need to use a computer, they visit an Internet cafe or the computer lab (if not locked).

How often do you access the Internet with one of your devices?

Thirty-seven students responded. Twenty-four (75%) are online daily, 13 (25%) 1-3 times a week.

What do you use your mobile phone for (and how frequently) for phone calls, SMS, WhatsApp, Web browsing, listening to music or watching videos, gaming?

Forty-eight students responded. Rating was performed with Likert Scores: never; once per week; more than once per week; daily; more than once daily; max. score = 5. Likert scores are shown in Table 4.18 .

Rank	Purpose (students, n=48)	Likert grades
1	Web browsing	4.15
2	Music, Video	3.52
3	Phone calls	3.52
4	SMS	3.24
5	WhatsApp	3.09
6	Gaming	2.94

Table 4.18 Students' use of mobile phones for different activities.

Students prefer Internet browsing. Interestingly, gaming is not very popular.

Additional questions

Are you using your mobile phone at school?

Forty students (82%, from 49) confirmed this, nine did not.

Do you use online material/tools/content for learning? (Table 4.19)

Students (n=50)	Yes	Yes %	*No*	*No%*
Internet browsing	39	78%	*11*	*22%*
Educational courses	38	76%	*12*	*24%*
Seek help for assessments	25	50%	*25*	*50%*
Participate in learning groups	21	42%	*29*	*58%*
Instructional videos	20	40%	*30*	*60%*
Games for learning purposes	19	38%	*31*	*62%*
Seek help (with peers)	18	36%	*32*	*64%*

Table 4.19 Students' use of different material for learning.

Which kind of content would be beneficial for your learning? (Table 4.20)

Students (n = 50)	Yes	Yes %	*No*	*No%*
eBooks	33	66%	*17*	*34%*
Tutorials	32	64%	*18*	*36%*
Lecture notes	29	58%	*21*	*42%*
Quizzes	24	48%	*26*	*52%*
Cooperative tools, cloud storage (Dropbox, Google+)	23	46%	*27*	*54%*
Slides e.g. Powerpoint, videos	21	42%	*29*	*58%*
Link lists	7	14%	*43*	*86%*

Table 4.20 Students' preferences for different sources.

Students appreciate eBooks for learning purposes; least-liked are link lists.

For which subjects do you use your mobile device? Subjects ranked (Table 4.21)

Subjects	*Students (n=50)*	*Subjects*	*Students (n=50*
Physics	27	Language/English	11
Chemistry	26	Health	9
Science	23	Agriculture	7
Computer Science	20	Geography	5
Mathematics, Biology	18	Arts, Geometry	4
Social Studies	15	Economics	2
History	12	Literature	1

Table 4.21 Ranking of subjects where mobile devices are used

Sciences are the leading subjects for using mobile phones for learning.

4.6.5 Post-workshop reflections, suggestions for future activities

At the end of the workshop, all participants reflected on experience gained in the course and created poster presentations of their visions of further developments.

Proposal for guiding the reflection:

- What do you think about the outcome of the workshop?
  Challenges, most liked …
- What would you like to tell your friends about the workshop?
- What do you take with you for future learning?
- Ideas about future use of your mobile phone and/or eReader for learning?
- What else would you like to let us know?

The first feedback was received in the form of handwritten statements; a blackout prevented use of the PCs in the computer lab (anonymous online survey was originally planned).

As soon as electricity was back, PowerPoint presentations about future ideas were created.

4.6.5.1.. Students' feedback

All students (n = 20) were encouraged to continue learning with mobile devices.

Summary of findings. Statements in original wording (*italics*)

Mobile phones can be used for academic purposes and content creation. Students explained ideas about future cooperation with peers to widen their horizons regarding opportunities for using mobile phones for more than entertainment. Furthermore, the necessity of guidelines for using mobile phones on campus was pointed out. Most of the students promised to tutor peers on best practice for learning purposes as well as to avoid unpleasant experiences with the use of mobile phones. Sharing material with peers was outlined as an important benefit for students' learning. They liked using the cloud, image tools, and posting and sharing their creations.

Portfolios were recognised as a great help for getting control over achievements. Students wanted to continue *'…got ability to create my own portfolio without assistance'.*

Creating eBooks was appreciated. Download of free-of-charge material was recognised as an option instead of *carrying heavy textbooks around*. Girls said that they started to read more; they were astonished by how much can be saved on a phone or an eReader.

Blog:

The possibility to '*let the world know what's going on within the workshop*' was very much appreciated; students continue with postings. Some boys promised to create a personal blog.

Challenges:

More than half of the students said that they are not allowed to use their mobile phones in school; most of them use it only outside of school for research.

Selection of statements and key perceptions

'*Workshop has been anything in one: stressful, hectic, fun, busy, joyful*'

Most liked

'We were taught things that we did not do in class before.'; 'very interactive'; 'most interesting was when we went around and learnt new creative ideas from others'; 'a lot of knowledge and skills acquired, e.g. 'responsible use, social network ethics'; 'great to know how to use mobile devices for learning'. 'Getting accustomed to eReaders in order to improve my academics'; 'amazing to read eBooks on my phone'.

Telling friends, dissemination

'In this workshop you develop hidden talents', 'it is a workshop where you must be! You can create your own blog, you can make research, assignments',' ....exploring the world, discover more technologies for future sake'.

What I have learned

'Weaving, learnt from the micro-units, which I have never done before, but now I can weave'. 'I learnt how to interview'.'... to share material with others'; '...really got an impact on my talents'; 'it created an avenue for me to learn new things', 'there are so many things I could not do before, like standing in front of my teachers'.

Take home message and future

A girl wanted to establish a club for further developments (Figure 4.30). Together with others she launched a mobile learning society (KETASCO MLS).

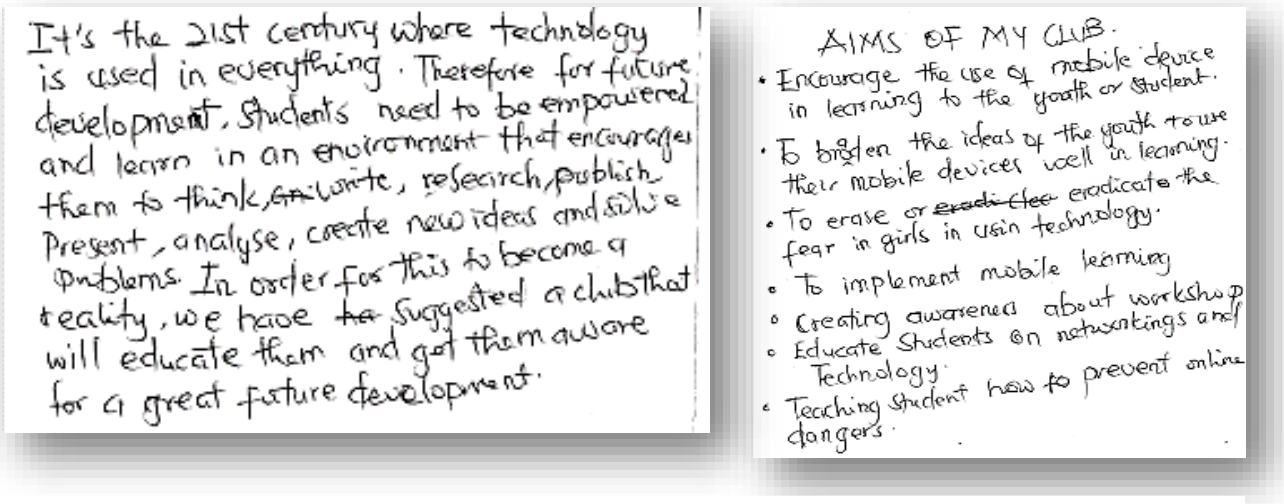


Figure 4.30 A female student's idea. Appendix 4.14 GIRLS CLUB Proposal 2014

'In the future I will use my phone to learn more and play little.' 'I want to encourage masters and teachers to allow students to use mobile phones for educational purposes which will make things easier for us', 'I want to create more content and even software', 'store my notes on an eReader'. 'I have come to a realisation that the more I try to use the mobile in my studies, I come across so many things that are really educative for my future,' '...we are now able to develop a blog for the entire school'.
MLS still exists at the time of writing. [56] (see section 5.8)

4.6.5.2.. Teachers' feedback, ideas about next steps: *What I want to do!*

Teachers (n = 10) reacted in very similar ways as students. Feedback was presented with Powerpoint slides and discussed in the group. Statements are clustered on the topics of teaching practice, integration of tools, portfolios and dissemination. Selected statements in original wording are included in order to provide more authentic insight into teachers' thoughts.

Teaching practice

New methods experienced in the workshop were considered to be integrated in class teaching, for example: teamwork, brainstorming, and use of video and audio recording. Teamwork and discussion will *'encourage more girls to take part in technology work and discussions'. 'I want to engage students more in teamwork to instil in them the spirit of cooperation', 'to make teaching and learning more effective'. 'Methods and techniques acquired shall become part of my everyday lessons'.*

The necessity of educating youth on rules of copyright, responsive use of mobile phones, social networks, online behaviour and avoiding misuse (bullying) was also stated as important issues that should be considered in daily practice.

Conducting interviews (video/audio recorded) and transcription was a new experience for both teachers and students.

Mobile phones are prohibited at school (Figure 4.31). The prohibition of mobile phones at school was heavily criticized (
'*Through this workshop I think mobile phones should be allowed. Though we go to ICT lab to make research, there are not enough computers to hold all students.'*

M. MOBILE PHONES
Mobile phones and personal stereos ARE NOT ALLOWED on school premises. These will be confiscated if seen or heard. This applies to both day and boarding students. Laptops are allowed ONLY during official periods - in the lab, classroom, or at sessions where note-taking is going on.

Figure 4.31 Pprohibition of mobile phones at school (official regulations)

[56] https://www.facebook.com/kmlsociety/

Integration of tools

The use of the cloud (Dropbox) '*for easy access'* was very much appreciated as a new and effective possibility for sharing material and supporting research activities. Creation of learning units and converting them into eBook format (with CALIBRE software) was recognised as another ideal option for delivering newly created material. '*….to educate students on the unique educational opportunities mobile devices are endowed with.' 'It supports students with updated material; micro content accessible with students' own devices provides access to it whenever they are in need for it'.*

Portfolios

Not only students were encouraged to continue with personal learning portfolios to track their learning. Teachers also mentioned some new ideas: '*It helps keeping track of my teaching and to serve as record of work'. 'Students' portfolios will be feedback on my lessons'. 'Reviews of students' portfolios will be used for diagnosis of their learning difficulties, progress and challenges.'*

Dissemination

A team of teachers promised to disseminate what was achieved in the workshop to other interested teachers, mainly the importance of proper use of mobile devices for learning. *'Other teachers will be engaged to design a set of guidelines on the acceptable use of mobile devices in the school', 'responsible use of social networks and the risks need to be involved.'…'educating students on the etiquette regarding the use of mobile phones in school';*

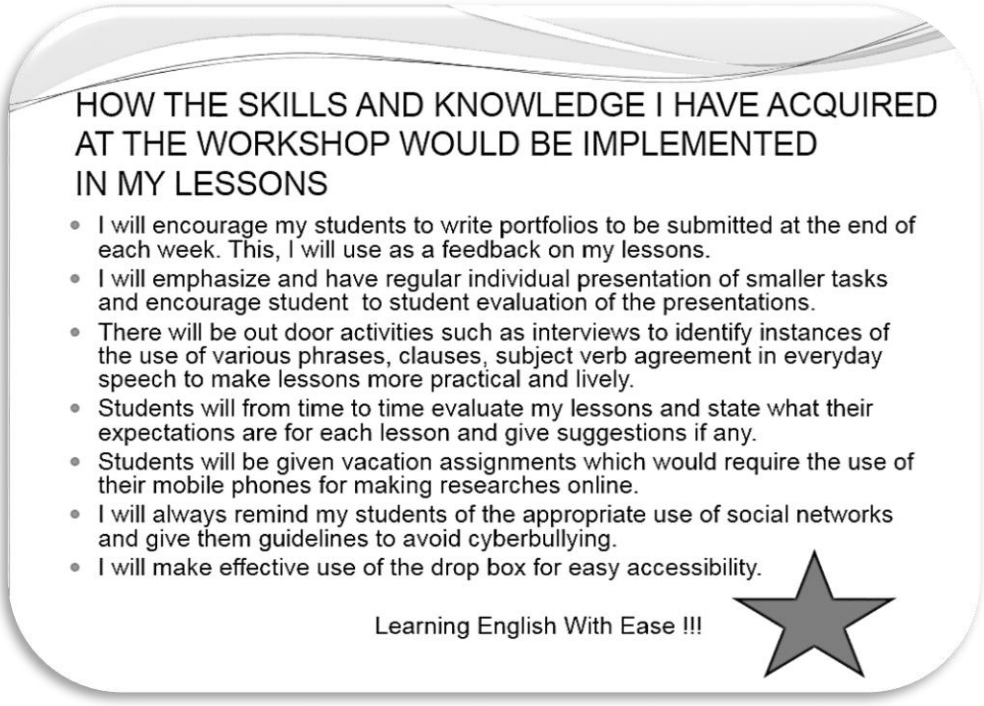


Figure 4.32 A teacher's summary of further activities

'I want to create a personal blog where information regarding my subject will be posted'. Presentations and posters were created for dissemination to colleagues (Figures 4.32, 4.33, Appendix 4.15)

Comments from a Biology and an English teacher

English Teacher: 'The workshop has really broadened our mind on how devices can be used. We have always thought the mobile phone is only for communicating but now I know the mobile phone can be used in making research. The students' English is actually impressive. I never expected that. Students are really doing well in their pronunciation, grammar, speaking and mostly in their writing too. Sometimes the students are better than the teachers are.'

Biology Teacher: 'Mobile phones will be used in completion of tasks. When students in senior high and technical schools will be allowed to use mobile devices in schools students can access their teachers' lessons, which have been integrating mobile phones. The micro content idea is to make teachers put their lessons into smaller units to be converted and put in a drop box for students to access on their mobile devices at anytime, anywhere, ,and teachers can also evaluate their students easily.'

Students and teachers presented their visions to the class.

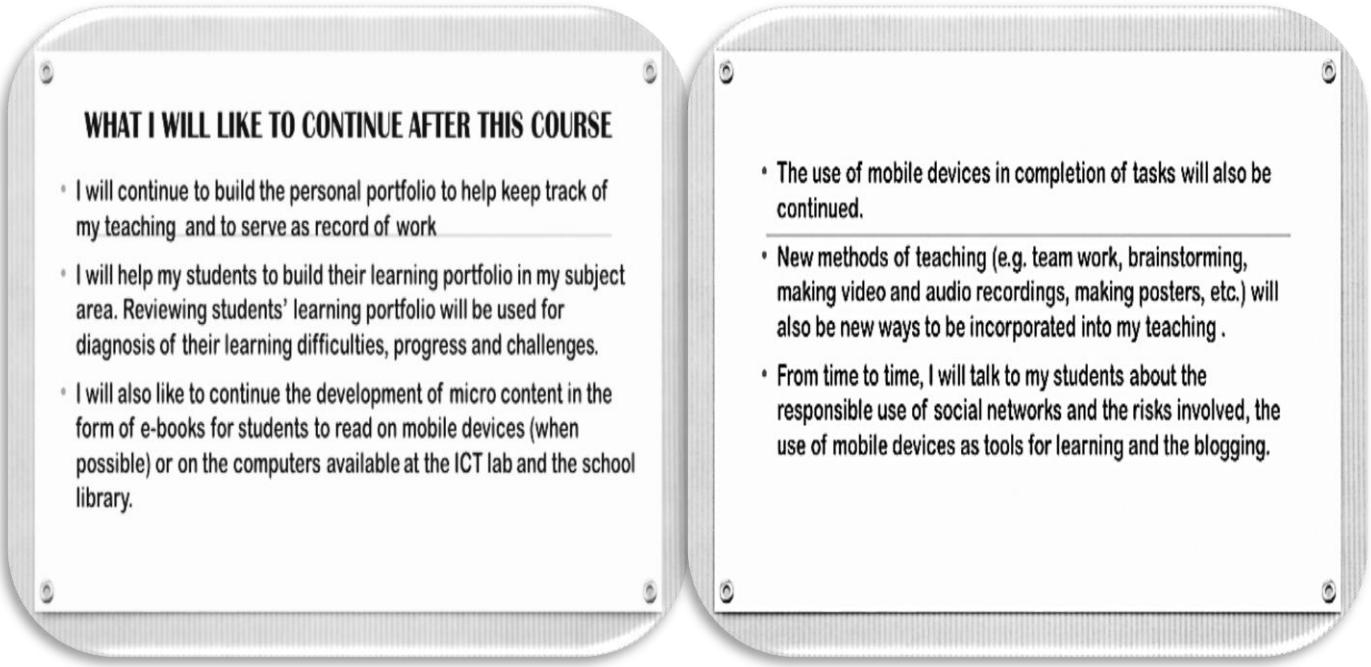


Figure 4.33 Ideas for activities in class-teaching

4.6.6 Interviews: perception of mobile learning

The aim of the interviews was to get some additional information from persons inside and outside the campus. Besides finding information, it was also intended to spread information about mobile learning on the campus.

The interviews were audio or video recorded on mobile phones for later referral. Workshop participants conducted interviews with other teachers and students on the campus. Interviews were semi-structured and open-ended. As an informal procedure, they allowed deepening of the overall findings and triangulation with other data sources. (Patton, 2002, Dick, 2005)

A total of 55 interviews were conducted, an overview is depicted in Table 4.22.

Interviewers (n=31)	Interviewees (n=55); Focus	Main topics
Students interviewed other students (n=20)	24 students. Use of mobile phones for learning	Main purpose for use of a personal mobile phone for learning; Expected benefits/challenges for learning? School, Subjects? Outside school? Internet at school? Restrictions, guidelines?
Teachers (n=10) interviewed colleagues from outside	18 teachers, 3 students. Attitude for mobile learning?	Devices for Internet research, subjects taught. Integration of mobile phones in teaching practice? Mobile phone on campus, in class?
Researcher interviewed teachers (workshop participants)	10 teachers: Workshop reflection and future plans	Perceptions: integrating new methods, practice? Mobile devices – benefits for students' learning? Increasing interest in STEM? Regulations, guidelines; outside learning activities: Mobile phones on campus?

Table 4.22 Outline of interview procedures

Structure of interviews

Guidelines were developed for the interviewers; they were encouraged to add questions in case other issues come up. The focus was laid on issues identified by means of the workshop feedback and surveys.

Transcription of interviews

The interviews were transcribed in the computer-lab. Each transcription was performed by two course participants because the pronunciation of the local English is hard to understand for a foreign researcher. Each interview was transcribed twice, performed with two independent teams (teacher & student) in order to assure correctness and consistency of transcripts, finally the two transcripts were compared and corrected.

4.6.6.1.. Interviews carried out by students*: Use of mobile phones for learning*.

Teams of 2-3 workshop participants interviewed peers from the campus. Main aspects, structure:

- Can you access the Internet with your mobile phone?
- Are you already using your mobile phone for learning?
- If Yes: What are you using it for (subjects)? If No: Why not?
- Would the use of a mobile phone be beneficial for students' learning? Suggestions?
- Are you using your mobile phone at school?
- Your expectations of using mobile phones in school?
- Can you access Internet at school/on campus? Wi-Fi?
- Are there any guidelines? (If Yes, define)… affecting you positively or negatively?
- Further comments

Findings: Student ⇨ Student interviews

Twenty-four peer interviews were carried out with 14 male and 10 female students, aged 16 – 18 years. Transcripts were coded into four main categories:

- Main purpose for use of a personal mobile phone for learning;
- Expected benefits/challenges for learning? School, subjects? Outside school?
- Internet at school? Restrictions, guidelines?
- Free comments.

Personal use for learning

Twenty-one students agreed with using a mobile phone for learning; three others said, because that it is not permitted in school and on campus, they use it at home. Most of the activities are not limited to a specific type of learning, e.g., *'to know more about what is happening in the world'.* The main purposes for use are research, mainly on relevant information in advance of assignments, for English (pronunciation, vocabulary) and for additional information not included in textbooks. Preferred subjects for research are: Crop husbandry, *'there is no textbook for this subject';* Biology (6x); Chemistry (6x), '*requires more research'*; Economics (3x); Elective Mathematics (4x); English (2x); Food and Nutrition; Geography (2x), Government (2x); ICT (4x); Integrated Science (3x); Literature; Physics (8x); Social studies (3x); Woodwork (2x) and Technical Drawing.

Applications used are Google Translate, dictionaries, encyclopaedias.

Benefits

All students agreed about the benefit from the use of mobile phones for learning. Many students believe that they would be more likely to engage in activities and discussions both inside and outside of class if they could use their mobile devices. Further statements: 'N*o necessity to*

carry textbooks around or to get out to town for research'; 'getting more information on what you need, the better is your success.'

School, Internet access, Wi-Fi

17 students had Internet access, but only in the computer lab; 4 did not know about Internet access at school; 7 stated that the lab is locked most of the time.

Wi-Fi in the lab is only accessible when ICT is scheduled, in a very restricted area close to the lab, and only for learning purposes, i.e. for download of music, videos, pictures, e-books and other learning material related to study programmes. Wi-Fi is protected with a password; main electricity is a major challenge. Answers to restrictions: *19 x Mobile phones are not allowed on the campus*. 21 x *No guidelines*.

Challenges

All students stated that mobile phones should be allowed to access information anytime, on topics they do not understand well and that are not part of the syllabi, for research on topics that are not covered in textbooks and for access to eBooks.

Free Comments

'The population of the school is about 2000 students; looking at the number of computers we have in the school, I think it will be better if we are allowed mobile phones in school to facilitate research and e-learning in the school. Using the mobile phone will be more efficient in accessing the Internet as compared to the school cafeteria'. 'We students flee walls and go to town to research, but if we are given this privilege, it will minimize the fleeing of walls.'

However: '*Some students might use the mobile phone for playing games, browsing the whole day and even to the extent of watching pornographic films, which in the long run affect them academically'*.

4.6.6.2.. Interviews carried out by teachers: *What is your attitude to mobile learning?*

Teachers participating in the workshop carried out 21 interviews, 18 with colleagues who had not participated in any of the workshops, and three with students.

The interviewers were asked to start with an introduction, informing colleagues about the course (approx. 5 sentences) before starting the interview. This was intended as an icebreaker and to spread information among other teachers. Main aspects addressed:

- Do you use your mobile phone for accessing the Internet?
- Do you integrate the use of Internet into your teaching activities?
  If Yes: Please explain; what works?
  If No: In which way could using Internet for teaching purposes be beneficial?
- If you use your mobile phone at school. For what? In what subjects?

- Views about students' learning: Do you think educational content accessible with mobile phones would be beneficial for students' learning? Please explain.
- What else do you want to let us know about your perceptions of mobile learning?

Findings: Teacher ⇨ Teacher interviews

Teachers who participated in the workshop provided information on the ongoing workshop and interviewed 18 colleagues about their ambitions for mobile learning: '*Do you think – whether, and in which way — could educational content accessible with use of mobile phones be beneficial for students' learning?*

Transcripts were coded into four main categories:

- Device use for Internet access, subjects taught.
- Integration of mobile phones in teaching practice?
- Mobile phones on campus, in class?
- Free comments.

Devices for Internet use, teaching subjects, purpose

All interviewed teachers use their mobile phones to access the Internet. It is the most common device for this purpose. Nine teachers additionally use a laptop, and two use a tablet or desktop computer for Internet access. Subjects taught: Biology (3 x), Mathematics (3 x), English (2 x), Economics, Electronics, Music, Social Studies.

The most popular activity is research. Most popular are Google search engines, YouTube and social networks (Facebook, WhatsApp). Reasons for research: '*…to get in-depth knowledge of the topic before I go to teach,' '…to download images, videos'. 'It gives me an update of all related research on the learning and teaching activities in my subjects.'*

Nobody mentioned the use of OER.

Integration in teaching practice

Only three teachers said that they do not use their mobile phone in class. Statements of others: '*I use it to clear all doubts on the students' mind';'… for consulting colleague teachers in certain experimental procedures'. 'I provide students with both British and American pronunciations, to check spellings, grammar etc.' 'I refer my students to certain websites for resources to enable them understand better. Some topics need more practical approaches to understand'. '…to take pictures and using those pictures in my design work'*; Music teacher: '*When they harmonize, they need to listen to what they have written; this will be put on the Internet, and plays it back to them to see if there is discord or no discord, it helps them to write a very good harmony'*.

Benefits / barriers of allowing students to use mobile phones on campus, in class

This topic led to many controversial answers and doubts. Six teachers would allow it on campus, but not in class. Positive arguments: '*It will benefit them if they are taught about the positive aspects of use of the devices'. 'It will be of great help. Students can make research on topics to be treated and that will make lessons more interactive, students can contribute a lot.'* Nearly all who had positive arguments added concerns about how proper regulation could be set in place. Besides misuse, there arose other arguments against, for example, *'It is hard for some students to pay their fees'.* Many other responses comprised a 'yes and no': '*Yes, if they will use it effectively, and No, because they will misuse it'. 'If only they can use it positively to enhance teaching and learning it will be good. I will be upset if the student is seen doing a different thing from what I am teaching.*'

Further comments

'When they are taught how to use it appropriately it will help. 'They must be guided to use the mobile phones to research on topics they are taught in the classroom. We need a lot of education on that.' 'We need to teach students to know how the mobile phone can be of benefit to the student. I think it is the mind-set being carried across.' 'If you restrict your students from using the phone, how can they compete with international students outside Ghana on examinations, who have been allowed to use the phone who use phones?' 'The project of providing laptops was not successful'.

Examples of how teachers introduced the purpose of the interview to their colleagues can be found in the Appendix.4.16 Interview introduction, teacher, 2014.

Additionally, teachers interviewed three students (two female and one male student).

Findings: Teacher ⇨ Student interviews

All three students use their mobile phone for educational purposes, mainly at home or outside the campus (because of the prohibition on campus). The students would appreciate mobile phones to be allowed for research purposes, because conducting research for assessments in the computer lab is time-consuming, and because they could do research in their leisure time on topics they had not understood well in class. '*It would encourage us all to perform well in school in the area of research', 'Link list, e-books, cooperative tools, for example drop box and Google+ would benefit us very much'. 'It would enable students to improve the use of technology without wasting much time.'* One girl expressed doubts about how this might be regulated: '*A disadvantage will be the challenge for senior prefects who will have in controlling its use in the dormitories late in the night'.*

4.6.6.3.. Researcher's interviews on teacher-participants' perceptions

The author's interviews were aimed at gaining deeper insights about the workshop achievements and expectations regarding future developments in practice. The findings were

coded in categories, clustered by focusing on issues such as tools, methods, challenges, and guidelines.

- Perceptions of integrating new methods in teaching.
- Mobile devices: benefits for students' learning? Increasing interest in STEM?
- Mobile phones on campus: regulations, guidelines, outside learning activities?
- Free comments

Findings: Researcher ⇨ Teacher interviews

New teaching

All teachers expressed appreciation for the tools and methods they became familiar with, which they had never used before or known about. The methods which gained most interest were using cooperative methods, tools for creating and sharing material, developing tasks in teams, providing students with material in the cloud for download, reviews, discussions and feedback: '*Mobile learning provides students with skills they need to become lifelong learners.' 'I think it is great sharing ideas with teachers and students. Because there you get the two parties and they can actually tell you what they like and don't like, so you can adjust teaching and delivery to them.'*

Teachers were enthusiastic about the use of portfolios as tools for recap and mentoring in the learning process: '*Portfolios are something that will be good to keep'.* Development of micro-content independently, in teams, even without teachers' aid, was outlined as an important enhancement from the pedagogical interventions: '*We are able to create micro content and students can access it by using the Dropbox'.*

Most said that they want to use new features, for example image editing, using snipping tools/screenshots, creating charts, using calculations for integration into worksheets and presentations. The option of video recording for subject-related purposes with mobile phones was outlined as very useful for future tasks: '*These new modalities are very helpful in designing new tasks and guiding students to become more self-directed learners'. 'These devices widen the horizon of learning possibilities.' 'It has opened my eyes to how to conduct research and how to impart it into my teaching.' 'For example chemistry, it is mostly theory, for the practical aspect I will pick images and use it for integration in learning.* English: …'l*earn pronunciation, record, listen to how we pronounce words and see the variety, and correct pronunciation in English.*

Effective use of mobile phones and eBooks (eReaders) for learning and STEM activities

The use of mobile devices for offering material to the students was most important. Many responses included notions on the use of tools for research addressing STEM-related activities. Integrated tools (camera, video, loudspeaker, etc.) were identified as helpful for creating ideas

about how '*new knowledge can be fetched',* when appropriately used 'it *helps to understand content better than with traditional methods and tools'.*

Regulations, guidelines for mobile phones on campus

Interestingly, all teachers supported allowing mobile phones for students' learning, by arguing that mobile devices help students to engage in learning. The use outside class was mentioned as very important, in '*bridging school learning with students' everyday learning'*. All referred to the necessity of *'developing skills for lifelong learning'*. *'From here, they are going into the bigger world and this is what they are going to meet. So if they practice the use of the devices here, it will help them in 'after school learning'. In specific cases no internet connection is involved, mobile phones are helpful supplements for interviews either audio or video, this does not need any internet access'.*

Teachers supported guidelines because 'to *educate students on how to use the device effectively is of high importance, in order to be in tune as to which areas to go to and some areas not to go to*'. '*We need to give them the guidelines, no matter what subject area we are teaching'. 'When you go to class, you should chip in this because I was really concerned about the cyberbullying and especially for teen girls who might be ignorant of what is happening and we fall victim to such threat.'. It will benefit them a lot to learn outside the school, except if they will run into other content, but if there is a way we could control them, I think it will help us so muc*h.'

Practice

Use of the cloud for students was rated as very helpful for distributing exercises and tasks for group work: *'In Physics for instance, there are some phenomena that cannot be treated without practical demonstration. I can use a mobile phone to take photographs or download videos on the practical of those phenomena and experiments, which can more lively demonstrate functionalities, than our textbooks'. 'In Ghana we don't have the equipment to do real experiments. In order to show some experiments I might download videos to see what happens during those experiments, so that all can understand it'. 'I realised many of the students were so dedicated; they wanted to know more about the topic; those who have mobile phones tried accessing more material and it's working very well. They download eBooks to read on some topics.'*

Comments

The overall very positive response to the workshop is visible from the open comments. Some teachers expressed the need for teachers and students to have their own laptop for smooth delivery of learning: '*We are aiming to introduce something that has been banned in school; as the more teacher accept the concept of mobile learning, the better is it for the whole school.'*
Teachers want to pass on the different options mobile devices provide with regard to the Internet

to their colleagues; they are looking forward to others getting inspired to practice mobile learning: *'More teachers should get involved.'*

Challenges

All teachers claimed the fluctuation of power and the instability of the Internet, the lack of computers and the insufficient maintenance of the equipment in the lab: *'No network or internet access is the problem! A stand by generator is needed, because there were so many light offs that stopped the course abruptly.' 'The computer lab is merely opened for instruction, not for all-time use by students. This makes gathering data for content creation a little hectic.'*

Recommendations

'Student spend just a fraction of their time in class. Most of their time, especially on weekends, they fiddle with their phones. They need to know how to use the mobile devices for learning.' 'There is so much content in the web. When you guide them, or they follow the guidelines, they are self-satisfactory with the use of the device and the teacher might not have too much work to guide them, because all is so woven into the processes. 'Students can access updated information from the Internet; they will not always need to rely on the textbook that are outdated. Mobile phones can serve as a teaching aid.'

4.6.7 Developed material, evaluation

Four experts (author, co-trainer and two educators from Accra) evaluated the created material independently, based on given criteria for evaluation; grading excellent = 1; good =2; acceptable = 3; poor = 4, evaluation not possible = 0; comments were added. The samples were discussed and a final grade was calculated based on the remarks of the examiners.

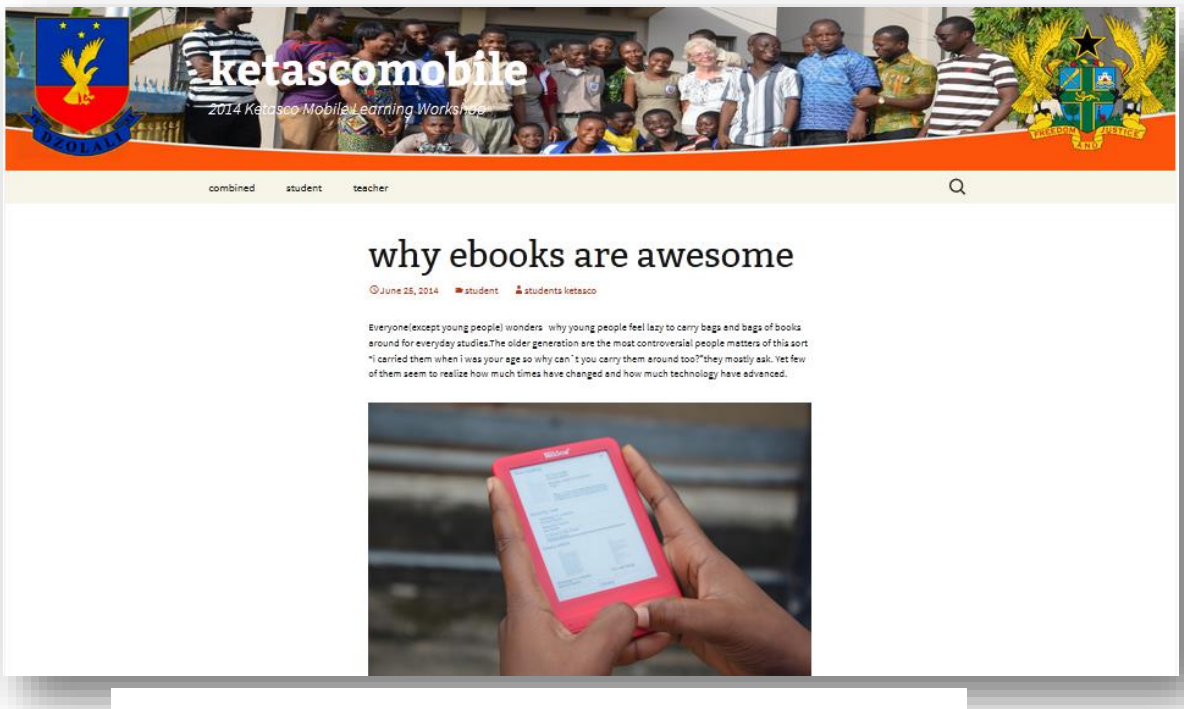


Figure 4.34 Blog ketascomobile (June 25, 2014)

Portfolios (n = 30 individuals): Assessment criteria: content and structure, individual comments and ideas for future work. Examples of teachers' reports can be found in the Appendix 4.17, and Appendix 4.18 (day 9).

Blog: A blog[57] of the project was developed in 2014 with sections for teachers and for students and was continued (Figure 4.34).
Learning units (micro-content, 10 topics, 10 teams).

Assessment criteria: structure and completeness of the learning material, course design, course objectives, screen design (eBook, mobile phone readability), visualisation (images, graphs, etc.), exercises (appropriateness). [58]

4.7 Summary of Findings, Reflection (Cycle 3)

Students and teachers were proud to show what was going on in the school to friends outside. Topics such as photo- and video- editing, transcription of video-recorded interviews and Blog-creation were favourites.

Benefits

- Teaching, pedagogy

Teachers experienced how mobile phones can enhance learning by taking pictures and videos, and how well these tools help students in enhancing the learning goals. In observing activities it was recognised that a shift from traditional class teaching (frontal teaching and rote learning) to student-centred methods developed.

Using participatory and creative methods in the workshop turned out to be very successful. It promoted creativity in defining and structuring small learning units and sharing learning experience on STEM-related topics. Team-teaching (the author together with the Austrian assistant) was set into practice as a model for future developments in class teaching. This partnership was reflected within the student-teacher teams.

- Micro-content for access with mobile devices

Content-development supports interactions and cooperation; content can easily be updated. It can be summarised that the created micro-content units are contextualised and culturally sensitive. Downloads can be shared via Bluetooth, it does not incur costs for mobile Internet.

- eBooks as supplement for learning

[57] http://grimus.or.at/ketascomobile/,

[58] Appendix 4.19, Learning Units English, Appendix 4.20, Learning Units Biology 1, Appendix 4.21, Learning Units Biology 2) paper version before compilation to eBook-format

eBooks became very popular; literature can be accessed for free from different web-sources. Students (mainly female) asked initially for assistance in search of reading material (literature and entertainment), later they were able to do so on their own and saved literature on their phones and eBook Readers.

- Strategies for web-search

Web search for retrieving material to enrich the content of a personal digital portfolio became a routine for students. Major search engines, for example Google Search, Bing Mobile or Yahoo!Search, were installed, because they have implemented a mobile-optimised version, which takes into consideration bandwidth and limitations of formats. Many apps for mobile phones are freely available and are used by students.

Challenge

The only challenge is the official prohibition of mobile phones on the campus.

4.8 Summary (Chapter 4)

This chapter provided a description of the three workshops in 2012 (professional development for teachers, enhancing digital literacy, impact on pedagogy), 2013 (content development for mobile devices, teacher-student cooperation) and 2014 (teamwork in STEM, guidelines and further practice in mobile learning activities). Activities are outlined in detail and examples for tasks are presented.

The findings gained in each embedded section were reflected upon and reviewed to improve the follow-up workshop. Examples of how challenges were overcome are explained, and successful strategies are explored.

Data collection and analysis are presented comprehensively to provide a deeper insight in local achievements, requirements and barriers.

Consequently, in chapter five the findings are summarised, discussed and conceptualised.

Further and on-going activities are briefly reported in Chapter 5.8, Research Follow-up: Developments from 2014 to date (spring 2017)

5. Interpretation and Discussion of Findings

5.1 Introduction

In this chapter, the findings of the research on the potential of a mobile learning intervention and an interpretation of findings / collected data, along with possible implications are presented.

This research study explicitly emphasised the use of mobile devices for learning as a supplement to improve development and education in a sub-Saharan African environment. The study aimed to determine critical factors for integration of mobile learning. Ghana is recognised as a digitally disadvantaged region of the African continent. (Quaicoe & Pata, 2015) A particular focus of this research is on understanding both resources (equipment and infrastructure) and the human factor (teacher readiness) for implementation of mobile learning.

The study investigated teacher and student readiness for new learning approaches and environmental factors using an action research methodology. Priorities and feasible strategies involved in integrating new learning with use of mobile devices in a Senior High School (SHS) in Ghana are explored. Data collection and analysis were performed along with an ongoing review of relevant literature.

Based on real-world experience in attempting new learning activities with mobile devices in a Ghanaian environment, the main issues that influenced the development process in this research study are categorised. Core sectors within the legal background for shaping the direction of interventions are *Infrastructure* (in school), *Teachers* (pedagogy, new learning) and *Students* (devices, ambitions), as depicted in Figure 5.1. These include

- Improving access to learning material, and
- The role of mobile devices in promoting new learning.

Success factors, challenges and attempts to cope with challenges are outlined in more depth in the following sections.

Aspects for promoting or constraining the development of ICT use in education in Ghana, and strategies to overcome barriers to integration of mobile learning in Ghanaian secondary schools are also discussed. It includes:

- National Policies in Ghana; review, consequences (see 2.10.3)
- ICT infrastructure; computer, Internet connectivity, mobile networks
- Teacher preparedness; readiness for pedagogical integration of ICT and mobile devices into education,
- Benefits and challenges for students in using mobile devices for learning
- Recommendations on how barriers might be overcome are outlined, based on the research findings.

This chapter concludes with examples of ongoing activities in the school (see 5.8), continued after the final workshop in 2014 until the time of writing (February 2017).

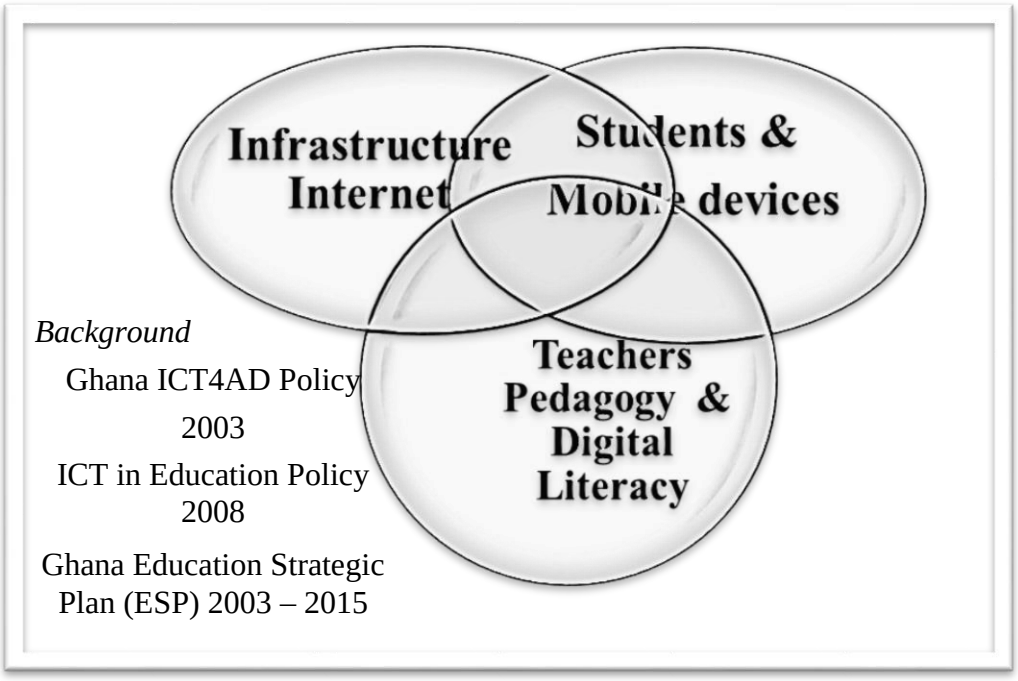


Figure 5.1 Contextualising main topics of this research.

5.2 Research questions

The initial research questions that guided and framed this study in order to conceptualise the framework of integrating learning with mobile devices in context of a SHS in Ghana were:

Qu 1. What are the most important issues to consider when planning the integration of mobile technologies in learning and teaching in a developing country in sub-Saharan Africa?

Qu 2. How can mobile learning be initiated as a beneficial supplement to education at a Senior High School in Ghana?

The research aims and objectives were addressed in three workshops (WS).

- *WS 1: Technology Literacy:* Utilising ICT for teaching and learning.
- *WS 2: Knowledge Deepening:* Enabling teachers and students to obtain better understanding by bridging theories with real-world problems on curricular topics.
- *WS 3: Knowledge creation and STEM*: Students and teachers co-create new knowledge required for prosperous societies.

The initial research questions were refined, and the initial mind-map of interrelated issues, depicted in Chapter 1, was redesigned and adapted, and is displayed in Figure 5.2.

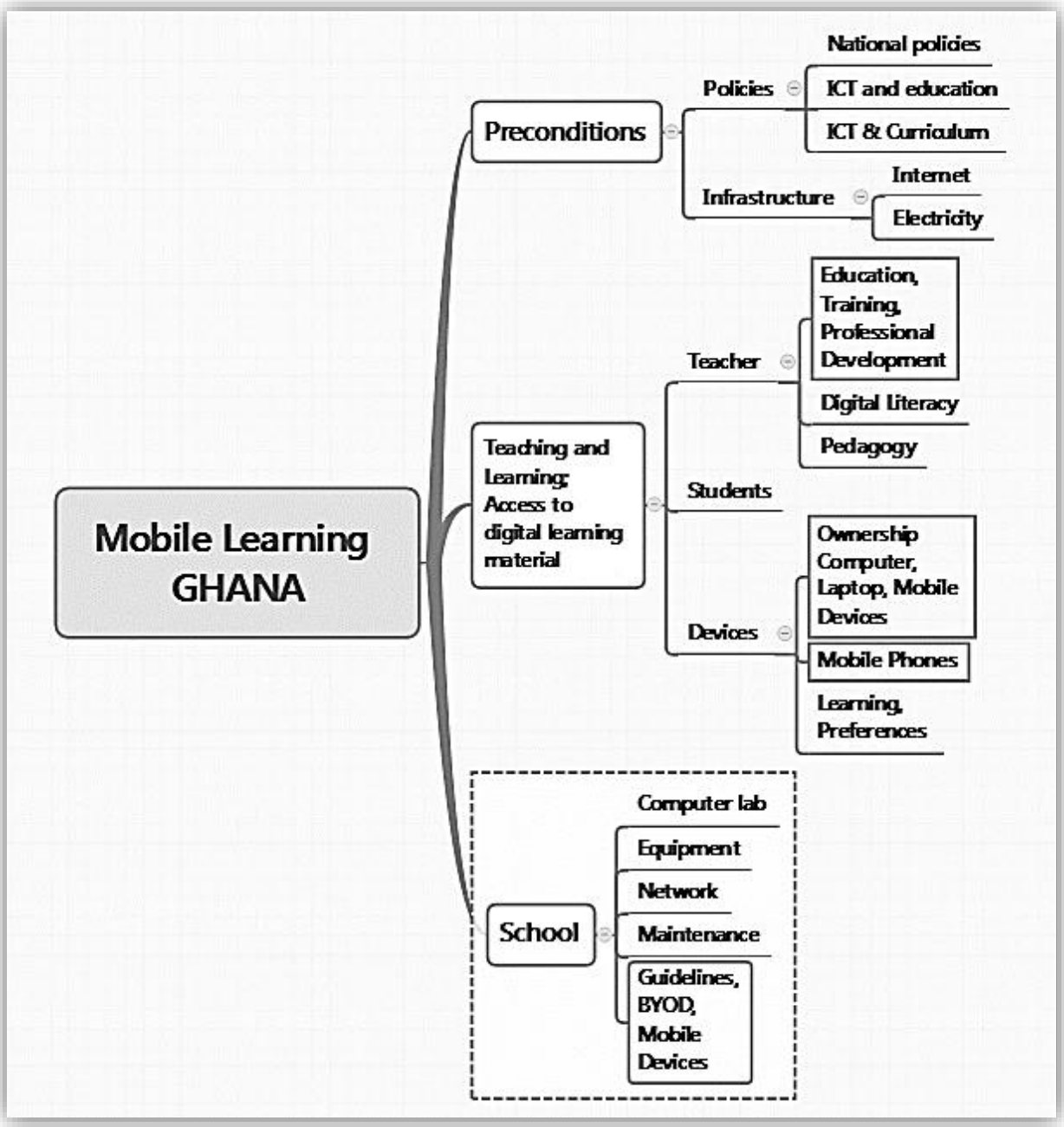


Figure 5.2 Mobile Learning in Ghana: refined structure of interrelated issues.

Sub-questions (SQu)

SQu 1. How can teachers be encouraged to integrate new pedagogical attempts including mobile learning activities, in their daily practice?

SQu 2. How can students assist in improving teaching and learning practice through integration of mobile learning in a traditional school system?

Sub-questions were refined in more depth based on the findings in the consecutive cycles.

Sub-questions in cycle 2

SQu 3. How can teachers be encouraged to expand teaching practice in such a way that learning with mobile devices can support students' learning?

SQu 4. How can students assist to trigger new pedagogical practice in a traditional school system in a fragile technical environment?

Sub-questions in cycle 3

SQu 5. How can teacher-student collaboration stimulate new educational practice to support development of locally relevant content?

SQu 6. How can mobile devices encourage STEM activities and trigger creativity in - generating new task designs?

Answers are outlined in section 5.5., based on the discussion of relevant factors in section 5.3 and 5.4 below.

5.3 Preconditions

The success of learning strategies with mobile devices is a consequence of the respective national government's support.

5.3.1 National ICT Policies in Education in Ghana

The *Ghana ICT for Accelerated Development* (ICT4AD) Policy dates back to 2003, and was updated in 2008 (see 2.10.3). ICT was introduced into the school curriculum at all levels of education by integration of ICT as a teaching tool for all subject areas. (Agyei 2013, p. 79)

Thus, ICT has been part of the Senior High School curriculum since 2008, defined in two curricula (Amenyedzi et al, 2011)

- Introduction of ICT as a core subject with a teaching syllabus for ICT (core);
- Introduction of ICT as an elective subject.

There are numerous obstacles to governments' visions of ICT to bring desired improvements in the reach and quality of education. Due to limited resources, there is no widespread use of ICT in schools.

The inadequacy of relevant resources for implementation of ICT, as outlined in the curriculum, was observed as an impediment for serious ICT integration. (Acquah, 2012; Danso & Kesseh, 2016; Malcalm, 2012; Buabeng-Andoh, 2012a) Although a computer-lab exists in most secondary institutions, obstacles in functionality of devices and high student-to-PC ratio (42:1 on average) hinder integration. (MOE 2009, Mereku et al, 2009; Agyei & Voogt, 2011). Such conditions make implementation of ICT with utilising computers in class teaching nearly impossible.

Hennessy (et al, 2010a) remark that when computers in schools can be used only on special occasions due to infrastructure limitations, 'they remain an object of curiosity rather than a useful tool.' (p. 97). Equipment in a computer-lab some distance from the classroom, particularly with large classes, is also an obstacle to its use. How computer-student ratios can restrict the practical use of computers, for example, how ICT is mainly taught, is illustrated with an example of an assessment in a technical SHS in Figure 5.3.

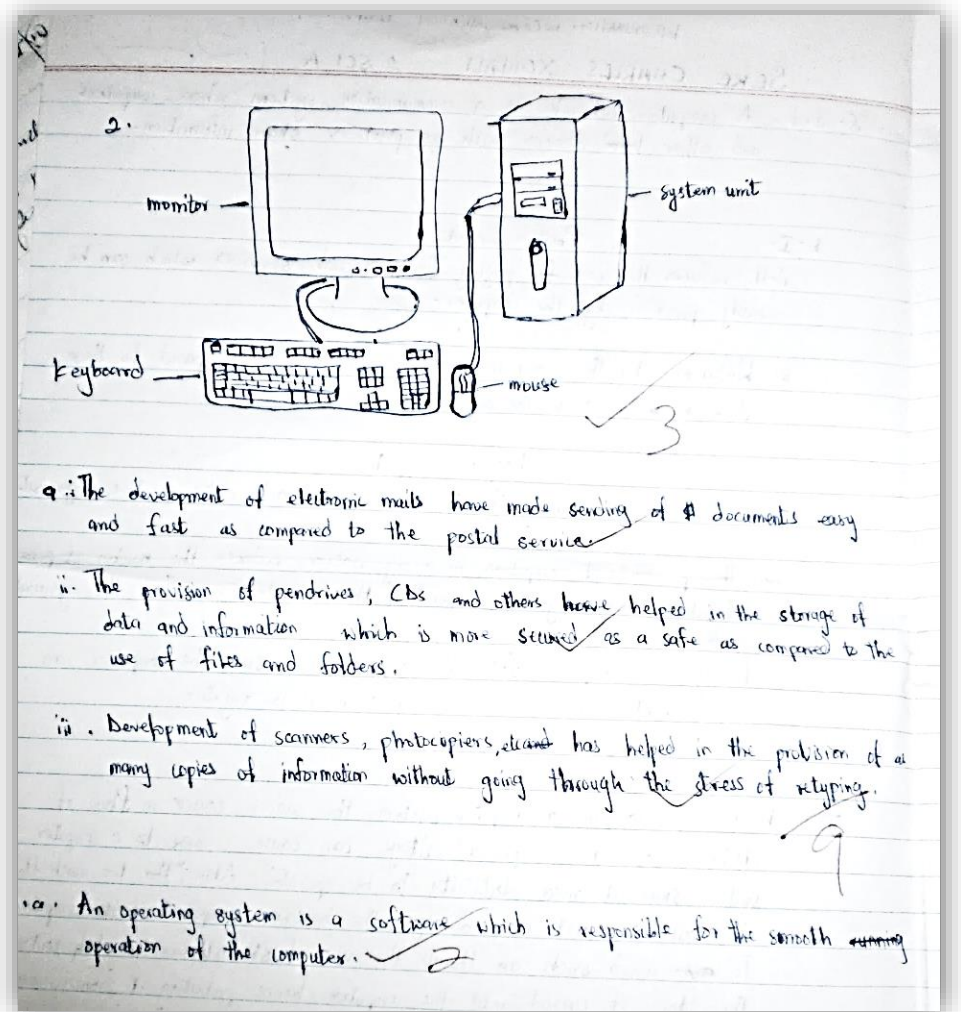


Figure 5.3 Example of an assessment, ICT in a SHS in 2013 (photo taken by the author)

5.3.2 Teachers and ICT

Teachers' attitudes play a key role in using computers as a learning tool and the likelihood of teachers to use ICT effectively. (Hennessy et al, 2010b; Oyerinde, 2014; Dzidonu, 2010; Osang et al, 2013; Quaicoe & Pata, 2015; Wright, 2014) Besides the inadequate infrastructure for the implementation of the ICT curriculum, a lack of teachers skills and training is pointed out by Agyei (2013, p.82). It is often accompanied by a lack of motivation based on resistance to change from traditional pedagogical methods to more innovative, technology-supported teaching and learning methods, which is affecting both students and teachers. He further indicates that the integration of ICT as a teaching tool for all subject areas is not a common

practice in Ghana. Most of the teachers do not have the level of competence (pedagogy associated with technological skills) to use ICT tools and equipment meaningfully in the teaching and learning process. (Agyei, & Voogt, 2011; Mereku &Yidana, 2012)

According to Agyei (2013), teachers are required to develop knowledge and skills to integrate ICT with a suitable pedagogical approach for teaching specific matter in a local context. He continues by stating that 'pre-service teacher training programmes of colleges of education and teaching universities provide little opportunity for trainees to learn skills necessary to integrate ICT into teaching.' (p.80) Beyond that, there is a need to develop appropriate content to enhance and support learning and teaching. The report on e-Readiness-Assessment (MOE 2009) indicated that only 9.4 % of a sample of 17,953 teaching staff are equipped with ICT integration skills; only 3.9% of teachers affirmed skills for content development. (Agyei 2013, p.81) Lecturers in tertiary institutions who participated in continuing professional development received less than 50 hours of training (Mereku & Yidana 2012). Emphasis on in-service training at the pre-tertiary and tertiary levels addresses only basic ICT skill acquisition. (Agyei, & Voogt, 2011; Mereku & Yidana 2012, p. 162)

5.4 Research Outcome

This study started with ideas about how activities using digital devices and web content for improvements in class teaching (current content instead of out-dated textbooks) and new methods (a shift away from rote learning) might be established in a Senior High School in Ghana. The research progressed into mobile learning and STEM activities.

This section summarises findings that constitute this research and comprises a variety of research topics covered within the general research problem.

Mobile technology holds significant potential for expanding the range of learning opportunities available to students and can support teacher training. According to Kearny (et al, 2012) research on mobile learning and teaching should consider the sociocultural perspective. This perspective provides a useful lens on pedagogical approaches and helps with reflection on teaching and learning activities, offering a critical insight into the design of tasks and material. Thus, the principle of self-sustainability through development of local capacity was addressed (Chapter 4 and section 2.5, Initiatives in SSA).

Data Collection, Overview

Data collection and documentation were conducted primarily during three workshops. The findings of this research are built upon the workshops. The first workshop (2012) was for teachers only. The second workshop (2013) started with teachers only; the second half was with students aged 15 to 19 years. In the final workshop (2014) one third of the participants were teachers, two thirds were students. It allowed redesigning and shaping the activity phases and surveys, and integrating new issues in subsequent workshops. This should be kept in mind in

considering the changes in research parameters in the context of this study. The results are cumulative in that the findings of each of the phases provided incremental results upon which the following phases were based. Table 5.1 presents a summary of topics in the workshops, comprising the main issues of this thesis.

Intervention	Aim	Findings
1st Workshop	To determine the school setting, teachers' readiness for change of teaching methods suited to integrate ICT into teaching in a developing country context with device ownership.	Resources: The lack of infrastructure and teachers' digital skills can be offset by flexibility in preparing instructions. Skill development in the areas of presentations, worksheets etc. for teaching purposes was achieved. Use of mobile phones (cameras, note-taking applications etc.) and traditional tools (white board, drafts in longhand, and posters) to overcome power-outages were identified as suitable strategies.
2nd Workshop	To study how cooperation of students and teachers can affect development of digital learning material aligned with teachers' existing factual knowledge.	Strategies: Experiencing tasks as examples for mobile learning. Mobile phones and eReaders contribute to learning by providing extended access to learning material, even with limited Internet access. Teamwork (teacher-student) in development of learning units improves collaboration, interaction and socio-cultural learning
3rd Workshop	To study possibilities for STEM integration and alternatives for using mobile phones for learning purposes and content development.	Suitability: Mobile phones and eReaders are viable and promising options for delivering additional resources for formal and informal learning in a developing country; e.g. mobile phones are advantageous in field studies. Development of strategies for lifelong learning was experienced in various tasks and investigations (instructional design). Mobile content is easily accessible and useful for promoting ubiquitous access for learning purposes. Guidelines need to be aligned with the environment (school, campus and infrastructure).

The outcome of the study showed that teachers and students valued and appreciated new directions in learning and teaching with integration of mobile phones and eReaders.

Table 5. 1 Condensed summary of research aims and findings in the workshops

5.4.1 Access to digital learning material

Key factors for integration of mobile devices in teaching and learning are access to digital learning material, devices, school lab equipment and Internet access, teacher readiness and skills (pedagogy, digital and local content), and student abilities and support. These issues are discussed in the following paragraphs in detail.

5.4.1.1.. Infrastructure in school, computer lab

15 desktop computers with Internet access in the school computer lab were confirmed in advance of planning the first workshop. On-site it was assumed that badly maintained hardware and scarce Internet connectivity was realised consistent over the research period. In the 2012 workshop it was only possible to access the Internet a few times during the last days. Beyond that, low bandwidth limited search procedures and up- and downloads in the subsequent workshops. Moreover, virus detection software was not - or could not - be updated, and frequent sudden power cuts affected the activities. Although the school principal was interested in developments in new learning with ICT, he stated that financial pressure limits funding of the Internet connection.

In the final workshop (2014), the Austrian co-tutor was busy with solving network problems, updating programmes and fixing the Internet connection. Finally, he discovered a couple of illegal downloads (videos, music) carried out with hidden laptops (not associated with course participants) as a reason for limited Internet connectivity. He succeeded in deactivating illegal downloads by changing the administrator password twice a day. In addition, he provided instructions for improved network management to the local administrator (see Appendix 5.1, Proposal for network-management). The document was handed over to the school principal. Unfortunately, on the last day-the co-tutor was requested to reset everything its status before the workshop (including the simple administration-password).

5.4.1.2.. Teachers' and students' ownership of (mobile) devices

Results on computer and mobile device ownership were obtained through consecutive online surveys with teachers in 2012 and 2013, and with students in 2013 and 2014. Student ownership of computers, laptops and tablets increased, however less than teacher ownership.

In 2010, the Ghanaian government started to provide free laptops to teachers at institutions with ICT laboratories for Senior High Schools, Colleges, Polytechnics and Universities (BIZTECH, 2014).

'The Ministry of Environment, Science, Technology and Innovation has distributed laptop computers to second cycle institutions under the "Better Ghana Agenda" laptop project instituted by the government in 2010.' [59] (ITU SIS Newslog (2014). The deployment of project laptops ended in 2013 (Ghanaweb, 2013). The laptops were assembled and designed in Ghana (Figure 5.4). The high level of teacher-laptop-ownership might be a consequence of the Better Ghana Agenda laptop project.

Figure 5.4 Better Ghana Agenda Laptop

In 2013, 65% of teachers reported permanent Internet access, with an additional 12% when Wi-Fi is available; 24% of teachers could not access the Internet with mobile devices.

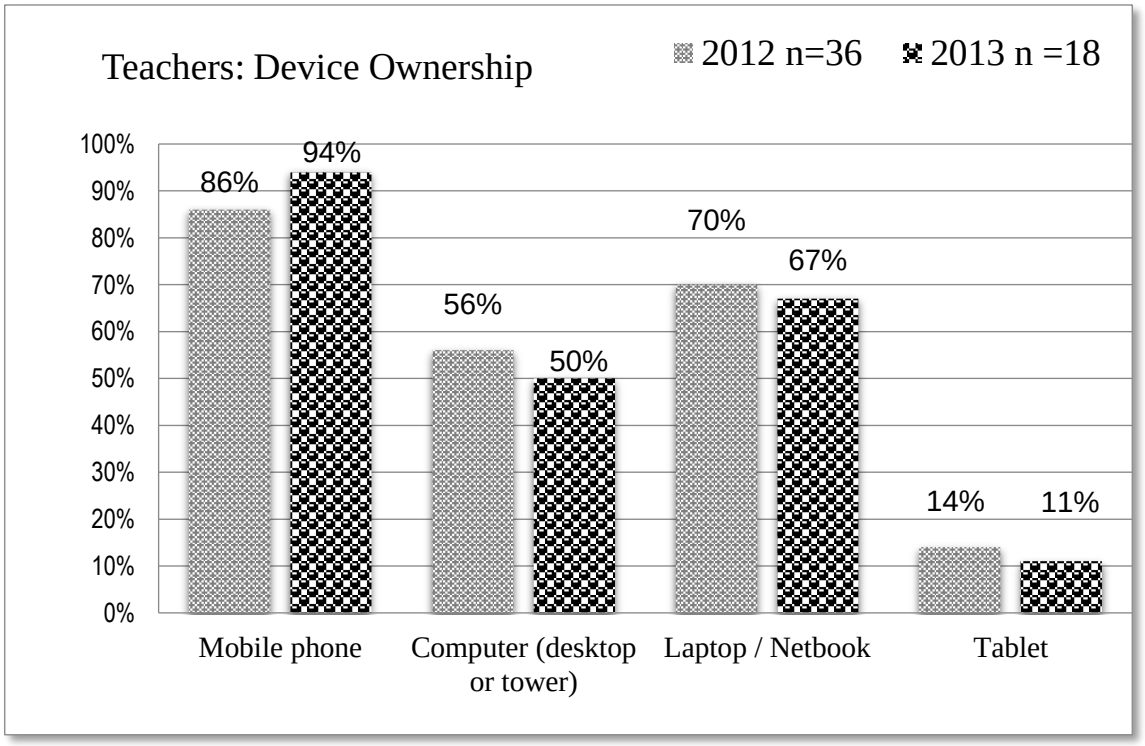


Figure 5.5 Teacher device ownership, 2012, 2013

A comparative analysis of data collected in the online surveys on ownership of devices is depicted in Figures 5.5 (teachers) and 5.6 (students). The minor decrease in other devices for teachers might be related to the fact that the total number of responses decreased to 50% compared to the previous year. Not surprisingly, ownership of mobile phones increased in both samples, reaching 100% for students in 2014; 70% reported ownership of smartphones with Internet accessibility

[59](http://www.betterghanaagenda.com/2015/08/07/ict-projects/, accessed 15/1/2016

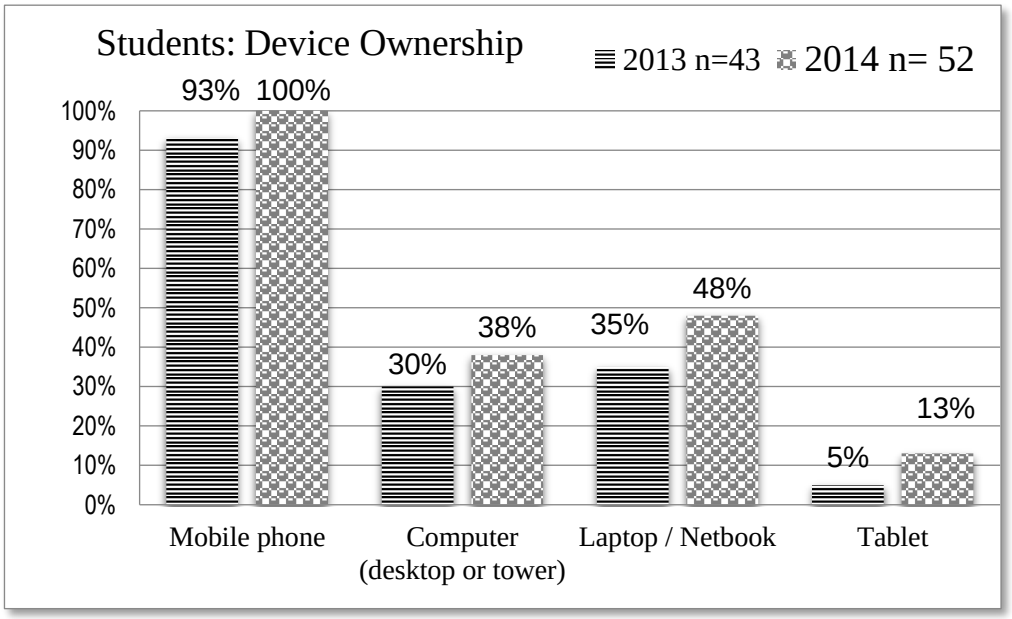


Figure 5.6 Student device ownership, 2013, 2014

In comparison, 77% of students reported permanent access to the Internet with mobile devices, with an additional 11% with Wi-Fi; only 10% of students had no access. Students responded Internet search is the most common activity in 2014. (Figure 5.7)

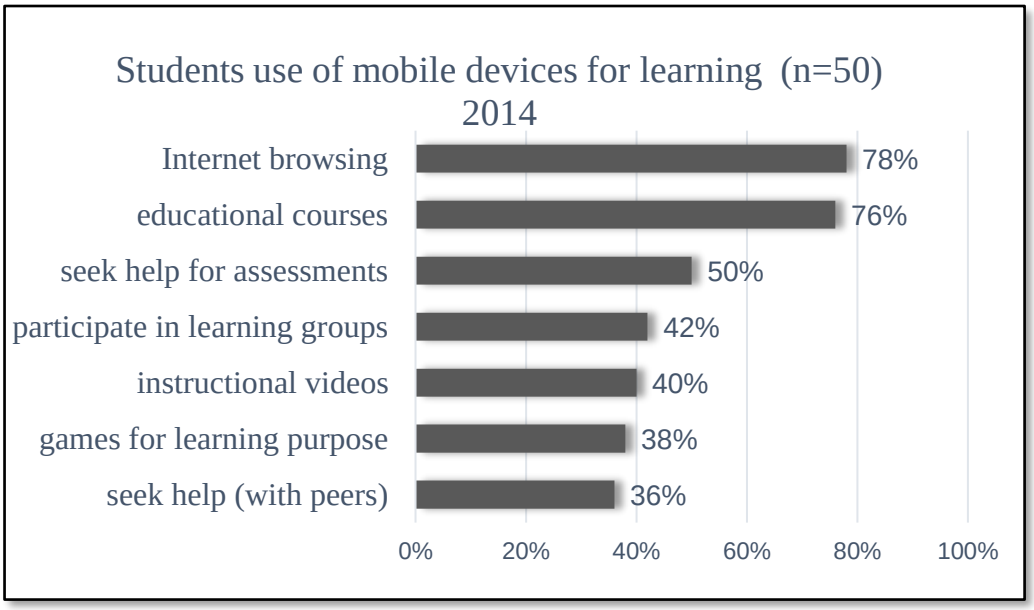


Figure 5.7 Students uses of mobile devices for learning (multiple answers)

Preferences for digital learning material

In 2012 teachers rated preferences for learning material from different points of view, a) from their profession as a teacher and b) what they think would be beneficial from a student's point of view , by using a 5-point Likert scale. (Figure 5.9) In 2013, teachers and students were asked a similar question, however, teachers expressed their perceptions as teachers; and students rated their individual preferences (Figure 5.8).

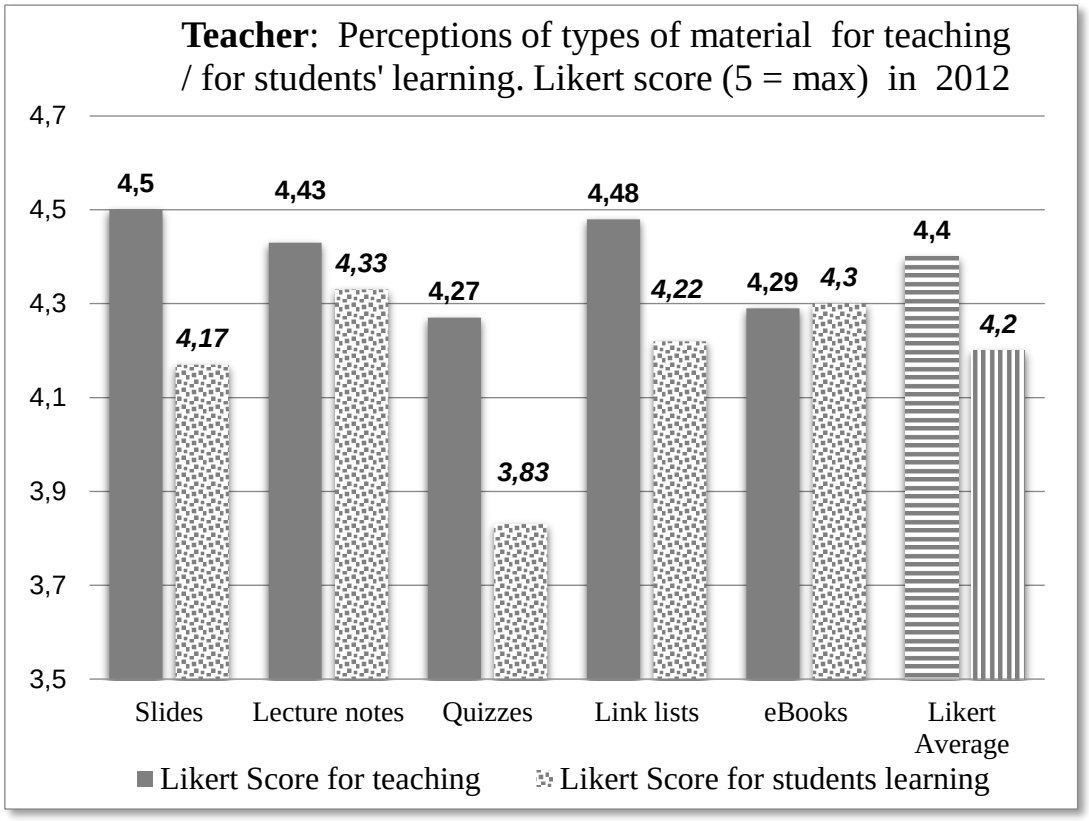


Figure 5.9 Teachers' perceptions of content beneficial a) for teaching and b) students learning in 2012

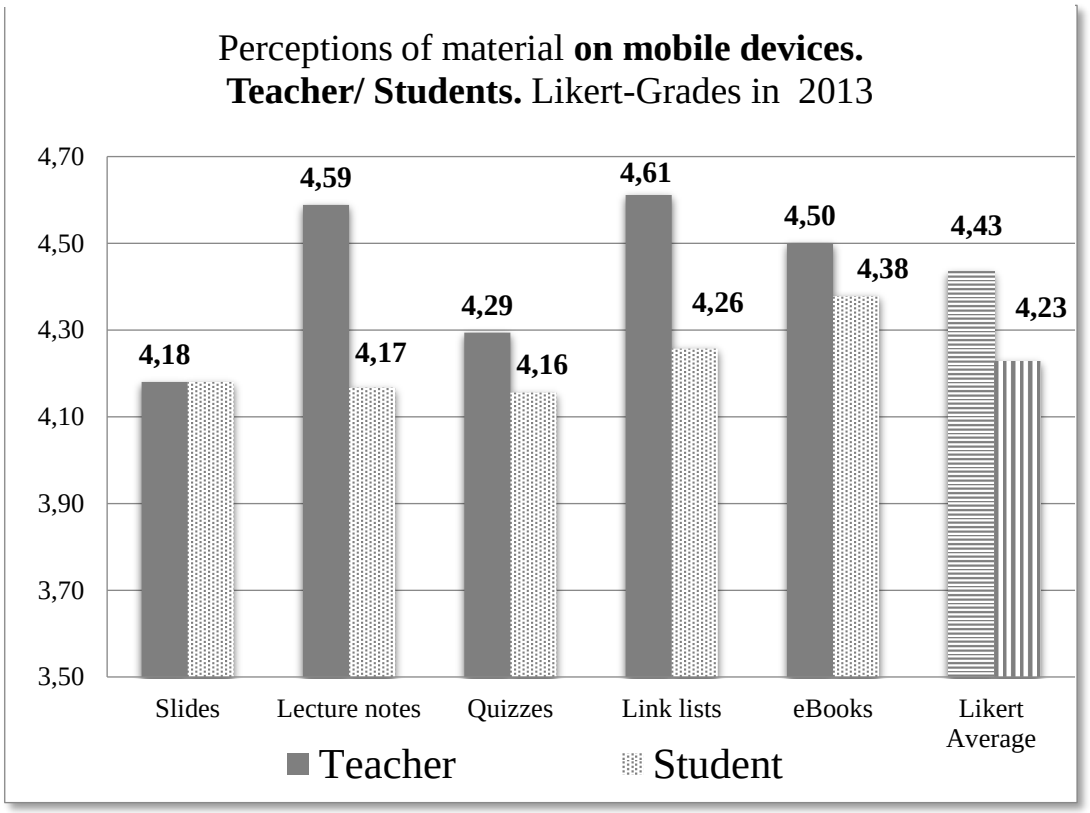


Figure 5.8 Teachers' and students' perceptions of course material in 2013

While there is no difference in the rating average between 2012 and 2013, the single items in

2013 show a lower rating from students than teachers' opinions of student preferences for content.

Students, asked in 2014 about preferences for resources with greatest benefit to learning rated eBooks highest (Figure 5.10)

5.4.1.3.. Summary - access to and preferences for digital learning material

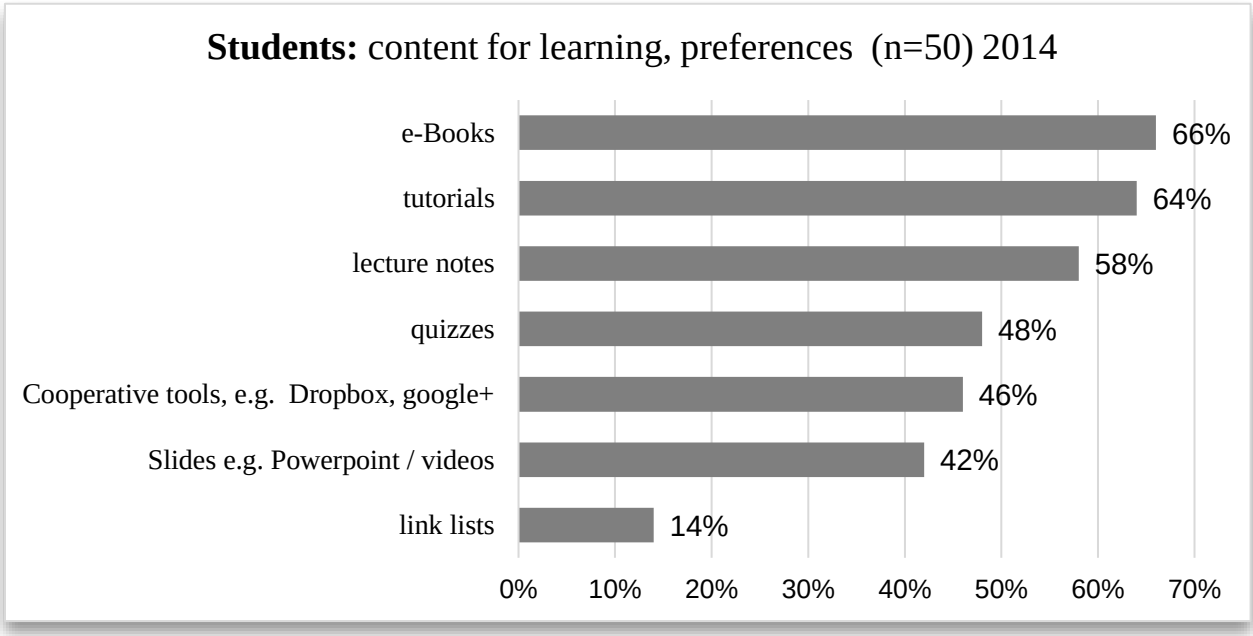


Figure 5.10 Student' preferences for various content (2014)

It can be assumed that, from students' perspective, it is feasible for most of them to access learning material with mobile devices (mainly mobile phones). Mobile phone features have also become extremely sophisticated. When looking to the vast increase in smartphone ownership, this might be an option for nearly all of them in the near future.

The scarce computers in the labs can be used for content creation. Utilisation of content accessible with mobile devices would compensate for limitations in the local environment, because mobile devices can be charged when electrical connections are stable, and batteries hold power for many hours.

Challenge

The main barrier for successful integration of mobile learning in schools is the legal prohibition of mobile phones in schools. Other impediments (affordability of devices, costs, digital skills of teachers and students, and different approaches in accordance with the curriculum) are discussed in the next paragraphs.

5.4.2 Roles: teachers students

5.4.2.1.. Teachers' readiness

Adoption of ICT in context with new modes in teaching and learning in Ghana is still in its early stages. According to Malcalm (2012), Boakye and Banini (2008), Toure (2008), Agey (2013) and Kozma (2008), the main issues for development are teachers' perceptions of change. This addresses traditional education and technology, and teacher training, focused on pedagogy combined with technology. Objectives of teachers' ICT competencies in SSA (based on the UNESCO competency framework for teachers) are outlined in detail in UNESCO IICBA (2016, p.76)

Based on the literature review and findings (outlined in 5.3.2) it was decided to address teachers' perceptions and preparedness first. If teachers have positive perceptions of the use of ICT, they can assist by providing useful insight for implementation. (Keengwe et al, 2008) This goes far beyond managing basic functions in computer use and office software. Teachers need to bridge the curriculum demands in their subject areas with a vision of what they can contribute to better outcomes with developing material and additional information from the Internet.

Only teachers who had expressed their interest in ICT and teaching in a voluntary application participated in the workshops. The workshops were scheduled in their free time to facilitate willingness and open minds.

Teachers tend to utilise technology based on their own pedagogical practices and their personal perspective on the curriculum. (Berking et al, 2012) The first workshop was devoted to preparing teachers for integrating computers and Internet in preparation for class teaching, and initiating changes in supporting learning. For example, the workshop heavily emphasised visualisation (statistical data, structuring information, etc.) Although digital skills were generally basic, teachers were highly motivated to learn how they could develop digital material. They were eager to create worksheets and other material accessible with computers that could be offered to students as an addition to textbooks, which are often out-dated.

In terms of pedagogical practice, teachers' attitudes influence their application of technological innovations. In terms of device-ownership, the majority of teachers was able to provide material for mobile devices, because about two thirds owned a computer or laptop for creating material. The other teachers were in a position to use computer labs for professional purposes. Thus, pedagogical practice depends on teachers' ability to create material. This might benefit not only their students, but moreover it could be shared with colleagues. This would be an advantage for colleagues and students in other schools, if the material is created based on a local curriculum.

It is necessary to find a means of external validation for the material developed. This can only be realised in cooperation with local staff. Within this research, evaluation on a local/national

level was only practicable to a limited extent. Four external teachers evaluated material created in the workshop (learning units, see 4.6.7).

Teachers became open to discussing and cooperating with students in developing learning material from the second workshop and on. The matter of teacher-student cooperation is a culturally sensitive topic. In this study, teachers agreed to it, and it contributed to shaping learning and teaching modes. Teacher-student cooperation contributed to new ideas for content presentation. Moreover, it increased creativity in research on updates of curriculum-related topics. Students are often more familiar with device handling and hands-on in developing new features than teachers, as it was mentioned by teachers in interviews (see 4.7).

Figure 5.11 shows how teachers' readiness for integration of mobile learning in practice was approached (workshop 1 to workshop 3). Teachers who change their instruction modes can, over time, inspire others to rethink their practice (Sammons et al, 2016).

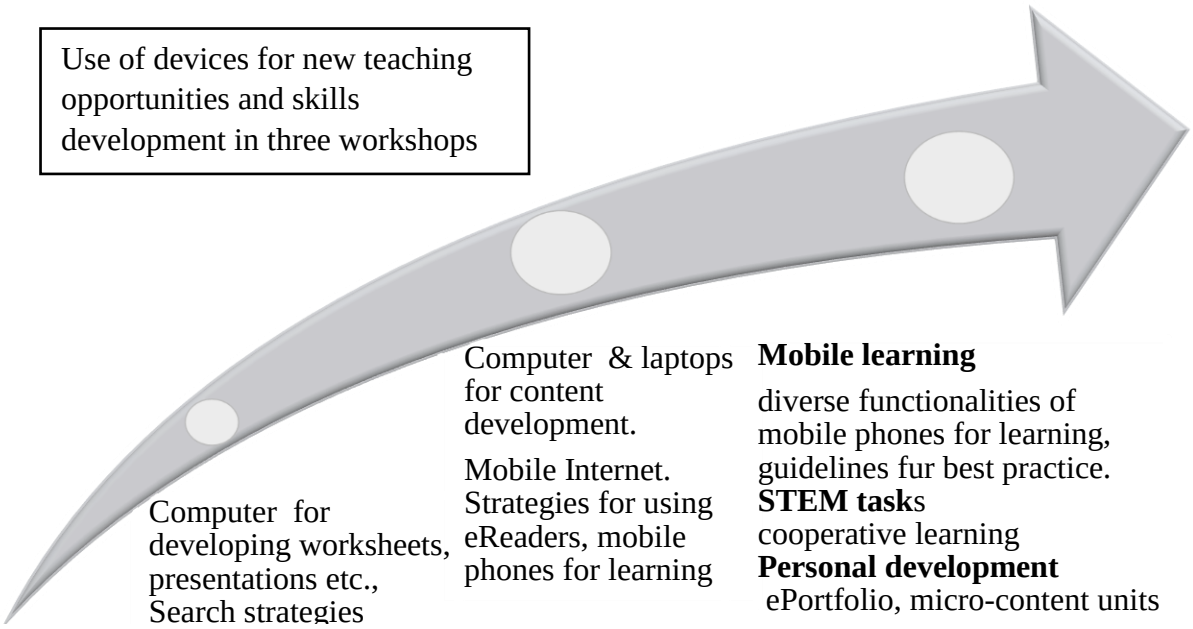


Figure 5.11 Devices and strategies for developing teacher readiness for ICT integration and towards mobile learning

5.4.2.2.. Students' benefits

Web search and information retrieval is based on access to quality online educational content, and plays an important role for students in developing countries, where resources are limited and textbooks are scarce. Thus, it is important to introduce new learning modes to students. They need new learning skills for further development, to be prepared for further qualifications (tertiary education, work-place, University), for using Open Distance Learning (ODL) or MOOCs for further certifications.

It can be assumed that youth own or have access to mobile phones, allowing them to access the Internet. It is also common sense that they are confident with the functionality of their devices.

Students in higher secondary schools (pre-tertiary level) are on their way to academic studies and presumed to be highly interested in new developments. Bridging learning inside the school with students' everyday lives means that students need to gain skills to become independent life-long learners. With regard to appropriate pedagogical interventions, it is a necessary precondition to understand students' mobile use and needs in their particular environment. Beyond that, it is important to foster youth's ability to master the risks associated with a mobile world.

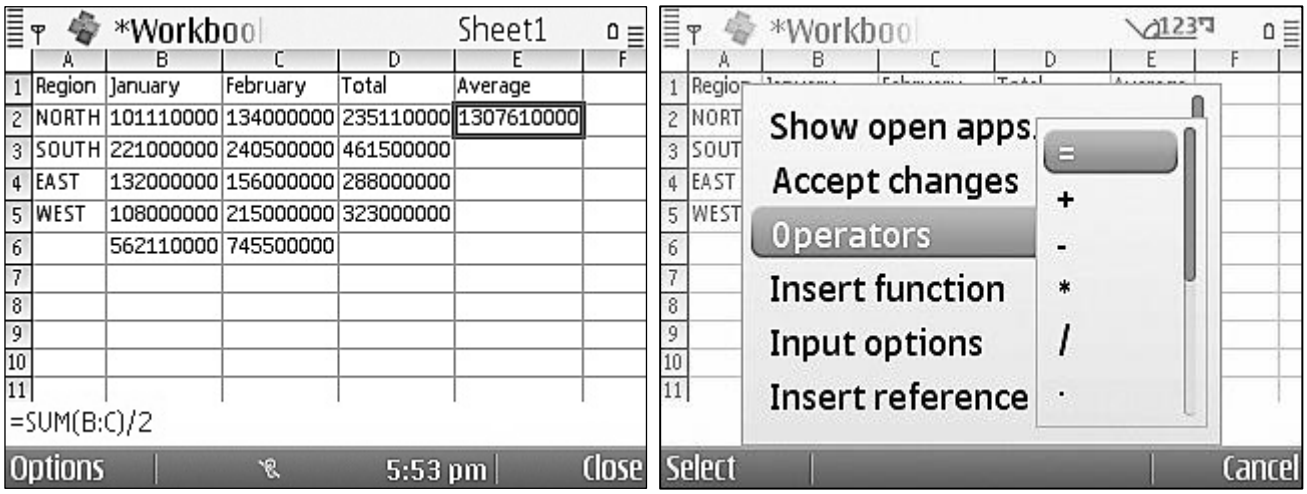


Figure 5.12 NOKIA phone- screens, display of calculation

The most common applications on students' mobile phones were dictionaries, Quickoffice, Adobe Acrobat etc. These applications allow elaborating on content retrieved via web-search; results can be saved, repeatedly read, translated, modified and shared (Figure 5.12).

5.4.3 Teaching.- Learning: mobile devices for learning, shifts in pedagogy

According to West (2013), advantages in educational innovation are based on teachers' training opportunities and professional development. This requires instruction on how to use mobile technology and how to engage students. Teachers need to be assured that technology can make their teaching interesting, easier, more fun for them and the students, more motivating and more enjoyable.

Although nearly all students participating in the workshops owned a mobile phone, relatively a few had experience with the device for learning purposes. Therefore, beside the initial goal of this research in enabling ICT integration in learning processes and further developments with mobile learning interventions, the potential for shifting traditional teaching methods in direction of social constructivist pedagogy was approached.

Benefits of mobile phones are not limited to increased access to educational material and learning opportunities. They can also facilitate changes in the character of learning modalities that can affect learning outcomes. (Sharples et al, 2007) Mobile phones encourage learner-

centred learning by enabling students to harness the transfer of and access to information to build on their skills and knowledge. Mobile phones also facilitate knowledge-centred learning by providing efficient methods for students to learn by deepening understanding of specific subject matter rather than merely memorising large amounts of information. This knowledge can be used as a basis for new learning through integration and interconnection (ibid).

In this research, collaborative learning was found to be a key benefit of mobile learning. It was observed that 'educational collaboration is more satisfying for students and teachers,' as outlined by West (2013, p. 8). Students and educators benefited from exchanging and sharing experience on various levels of knowledge (scientific as well as usability of devices).

The Pedagogy-Andragogy-Heutagogy (PAH) continuum (Blaschke, 2012; Luckin et al, 2010) was used as a theoretical background for investigating possibilities for shaping education in context of the introduction of mobile learning. These attempts at shifting pedagogy and learning methods were integrated into the workshops as outlined in Figure 5.13 (workshop 1 to workshop 3).

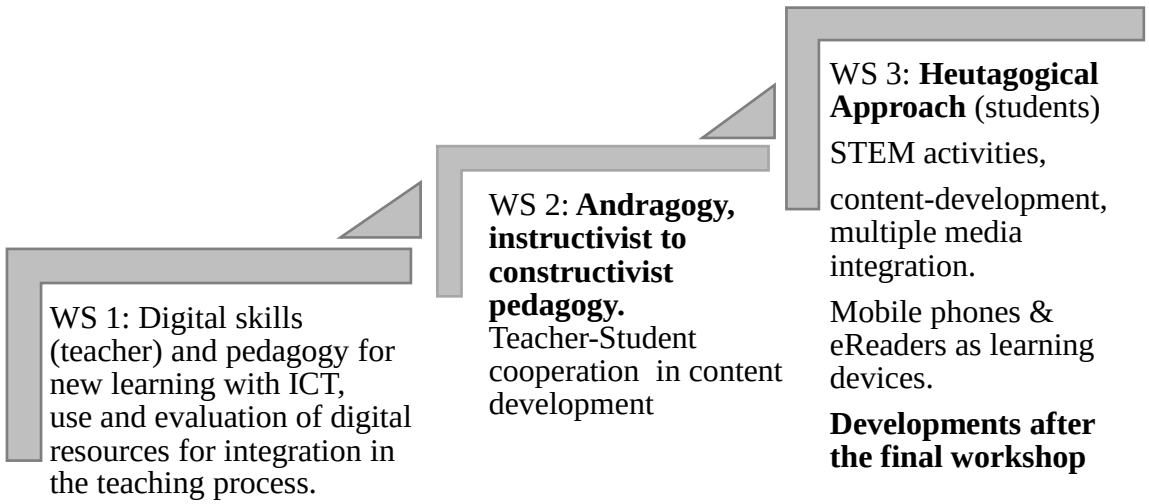


Figure 5.13 Attempts to change learning modes by integrating ICT in three workshops

5.4.4 Content development, STEM, guidelines, teamwork

According to Berking (et al, 2012) mobile learning and mobile performance support are related and harnesses informal learning. Quinn (2010) describes three types of performance support (performance augmentation) for mobile learning as:

- Media capability – user generated content (camera, editing software etc.)
- Data processing ability (calculators, decision making abilities)
- Communication ability (connecting with other learners)

Adapted from Quinn, 2010

These disciplines were addressed through content development and STEM activities, because they add value in designing learning units and tasks.

Because teachers were not aware of digital local content, development of small learning units became an important issue in the workshops. Most of the material retrieved from the web needs to be adapted to meet local demands and curriculum. After adaption (using a PC or laptop) the relevant content for subject-teaching (micro-learning units) was compiled into formats accessible with e-book Readers and mobile phones (ePub, pdf, mobile versions), allowing online and offline use (Figure 5.14)

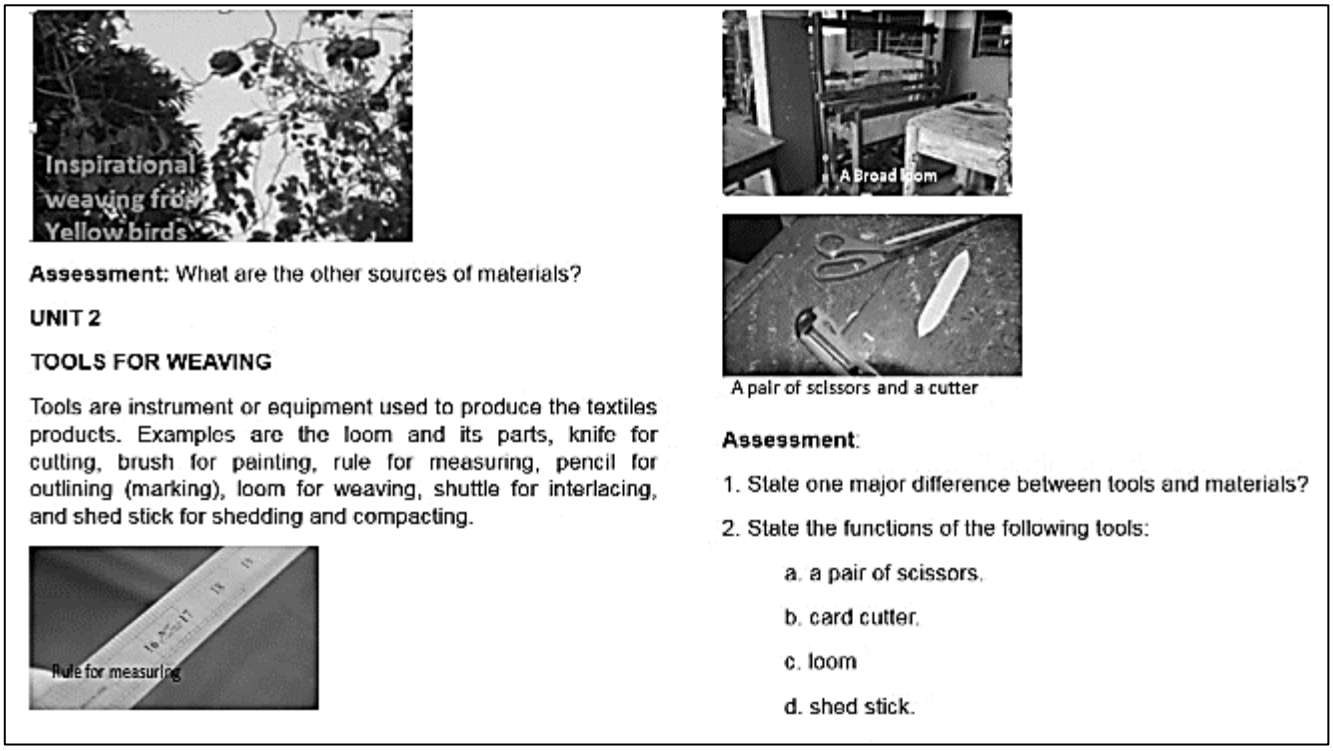


Figure 5.14 Micro-content on the subject of textiles

Students are encouraged to develop a number of transferable skills. According to Grzega and Schöner (2008, p.169) 'learners are given the chance to acquire creativity, independence, self-confidence and key competencies, such as the ability to work in teams, the ability to communicate, complex thinking, the ability to seek and find information, […] the ability to structure information and generate knowledge, punctuality, reliability and patience'. They further point out that it increases 'presentation skills' and 'project competence.'

Co-creation of content provides additional value. It reflects students' demands for actuality of content and upgrades results. Structuring learning units was a key topic. Teachers explained topics related to their subjects according to the curriculum. Student-teacher teams worked in research and unit-creation, evaluation of online content, and taking photos and videos for illustrating the content. Such learning units are easy to update. Students contributed with questions; this often led to extended research and integration of additional information, demonstrated with the interest of a student on a textile technique (Figure 5.15).

STEM activities provide students with the opportunity to bridge the gap between theory and practice. Research requires problem solving strategies, abstract thinking, digital skills (search, structure, present, visualise), clear explanations and creativity. Research on topics in their environment can produce material for fellow students. They can work in teams on collaborative projects for which they need to structure content and present it in an appropriate format (see 5.8.1. Further developments).

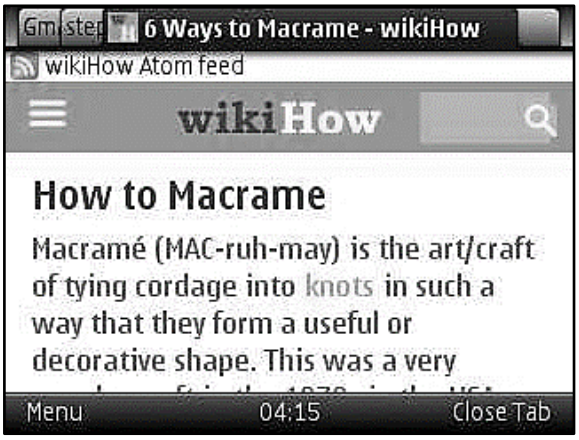


Figure 5.15 Web-search result displayed on a NOKIA phone (subject of textiles)

In content-creation, it was frequently observed that students took over the teaching role. Teachers began to appreciate this kind of assistance, mainly with regard to technical demands. The method of learning by teaching, developed by Martin (1985) is acknowledged as enhancing students' learning experience by encouraging them to teach other students and collaborate with other learners.

Development of personal digital portfolios was an additional issue in the workshops. It was recommended to complement contributions to the portfolio by adding web references for relevant topics. Portfolios were anticipated as a useful experience, and this was continued after the workshop in daily practice. For the development of portfolios and content creation it is recommended to use laptops or PCs, due to limitations of screen display and input options when using mobile phones for this purpose.

5.4.4.1.. Guidelines - Good Practice

Based on the findings in the surveys, it can be concluded that teachers' perceptions of integration of mobile devices for learning are positive. This was affected in the second workshop, where mobile phones in students' hands led to a better understanding of the issues than theoretical statements. In the workshop, teachers experienced benefits and challenges together with students, and developed guidelines for good practice using mobile devices for learning. A similar expectation was gained in the interview with the headmaster, who pointed out that using material available online for knowledge creation could help with becoming better critical thinkers. He referred to new didactical methods and benefits by integrating mobile devices in learning and teaching and promised a reform of guidelines for use of mobile devices (mobile phones and eBooks).

5.4.5 BYOD strategy (Bring Your Own Device)

Insufficient access to computers and Internet can be partly compensated with a shift from computer-dependent ICT use to integrated mobile device features (in mobile phones, eBook

Readers). The ubiquity of mobile phones means that educational content can be accessed with learners' existing resources. The advantage of using mobile phones to improve educational outcomes in developing countries is stated in the study published by Valk (et al, 2010).

Access to mobile phones during STEM activities demonstrated the potential for transforming and improving students' experiences with taking notes and using the camera function of their own devices. It is a very important fact that students are familiar with using their own devices, it decreases costs for service and support. Beyond that, it should be mentioned that students take much better care of owned devices than devices provided for free. If the network is safely maintained, Internet costs would not increase too much when students use Wi-Fi in the computer lab.

In order to minimise personal mobile connection costs, content was generated in the computer-lab, compiled, and saved on the local network. In the second workshop, frequent attempts for compilation were needed with using ABC, due to limited Internet connectivity (details in 4.3). In the following workshop, CALIBRI software was locally installed, offering off-line content conversion.

Using a cloud service for downloading and sharing material to owned devices was also highly appreciated. Notebooks and mobile phones can be used for much longer periods without recharging. Most notably, many power outages could be bridged with mobile devices, allowing continued learning during power outages. This allows using multiple functionalities of the mobile devices for a variety of tasks even when electricity is down.

Content (web) and micro-content units on mobile phones can be shared via Bluetooth in order to overcome the high costs of data plans. Built-in Secure Digital (SD) cards hold content that can be accessed at any time for further studies and used for enrichment of reports and e-portfolios.

5.4.6 Gender

Regarding the gender dimension, there was very low participation of female teachers in the workshops (only one female teacher participated). In this regard, it should be noted that females accounted for 40% of the student-participants. Female students founded the Mobile Learning Society (MLS) as a follow up to the third workshop. They are still very active with further developments and organising workshops (see Further Developments in 5.8).

5.5 Answers to research questions

Qu 1. What are the most important issues to consider when planning the integration of mobile technologies in learning and teaching in a developing country in sub-Saharan Africa?

Infrastructure and policies in education

Acquiring information about the equipment in schools is a critical issue. A main challenge is the lack of adequate ICT infrastructure, along with irregular electrical power supply. Based on a literature review it can be summarised that the conditions in school-computer-labs in Ghana are generally poor. (Malcalm, 2012) A gap between the information provided officially and the school-reality was observed in the research. A similar view is expressed by Buabeng-Andoh (2015): 'Lack of adequate hardware and software reduces the whole objective of Ghana's ICT4AD to absurdity'.

Leapfrogging the computer era in developing countries provides the chance to use mobile technology instead of and as a supplement to computers. BYOD can be a perfect option for coping with the impediments mentioned above. However, the use of mobile phones for learning needs to be in line with physical device limitations, such as processing power, data storage, connection method and battery consumption, in accordance with the need for scrolling and navigation. Beyond that, dealing with prohibition of mobile devices in schools must be handled very carefully.

In April 2014 Wright published '5 Key Barriers to Educational Technology Adoption in the developing World. (Wright, 2014): Electric power, Internet connectivity, training and professional development, valued teachers and sustainability. His findings confirm the most important barriers, which were observed and outlined in this research.

Qu 2. How can mobile learning be initiated as a beneficial supplement to education at a Senior High School in Ghana?

School level

From the literature, it can be determined that the failures of many programmes are related to the fact that schools are often provided with hardware (computers) but little or no support is provided for teachers' professional development. (Buabeng-Andoh, 2015; Malcalm, 2012; Agyei, 2013; Agyei & Voogt, 2011) It is recommended to come to an early agreement with a positive-minded principal. This is an important issue for planning a workshop where teachers are using the equipment in an environment of their daily practice. To recruit teachers for training in an outside location with equipment different from that in their schools often turns out as not successful on the long run.

5.5.1 Answers to sub-questions formulated during the research in order to gain deeper insights.

SQu 1. How can teachers be encouraged to integrate new pedagogical attempts, including mobile learning activities, in their daily practice?

A critical issue is the motivation of teachers; it is reasonable to take in only highly motivated teachers for a first workshop. A pre-survey for application as a starting point is a good premise to recruit interested and open-minded participants. Participants are well inclined afterward to discuss newly gained knowledge with colleagues and share practical experience with staff interested in educational developments. Such a 'snowball effect' was observed by the researcher in previous workshops, where new methods obviously evolved in the school.

Workshops and schedules

Most in-service training lasts only for a couple of hours or at least two or three days, often provided in an outside location, with teachers from different schools.

In this research, three workshops were organised in the school, with long breaks between the workshops. A workshop comprised a minimum of 60 hours, and additional hours for individual practice when demanded. This allows time for experiencing different methods and functionalities, and for asking and discussing question regarding unclear or new issues. Between the workshops the teachers tried out new tasks and pedagogical interventions with their students in real class-environment. It is recommended not to organise only one workshop and leave the staff thereafter on their own for coping with local problems when returning to school.

The follow-up workshops were performed on a higher level; challenges observed in real class settings were discussed in the group in order to find practicable solutions for the situation.

Reflection

A collaborative partnership supports understanding of new developments and pedagogical interventions. In the initial workshop, teachers developed skills in using computers in the computer lab and private laptops (when available) for development of supportive learning material. They discussed ideas of how new skills can be integrated in class teaching together with didactical attempts for changes in teaching practice. They realised their role as teachers and as learners at the same time when working in teams and providing feedback on presentations of colleagues. Teachers reflected on methodological issues by co-creating new teaching and learning settings appropriate to the environment. Beyond this, they witnessed the reality of unexpected situations when sudden power outages interrupted highly focused work on computers. They also witnessed the importance of flexible planning the instructional design to overcome unexpected breaks in a flow.

SQu 2. How can students assist in improving teaching and learning practice through integration of mobile devices for learning in a traditional school system?

Using mobile phones for new learning activities was experienced along with integrating students in the workshops. Interdisciplinary activities are not widely known in schools in

Ghana. Teachers and students identified together advantages in developing and structuring small learning units, illustrating content, video-recording experiments and procedures, which are thereafter available on mobile devices, which can be shared and integrated in learning material.

Generating learning material for mobile devices increases knowledge-development for both parts. Discussing ideas for anticipated learning goals in teams can improve the actuality and quality for lesson planning and content-creation. Various functionalities of mobile devices for learning (e.g. voice-recording, taking notes, photos, and videos) were tried out and tested in teams. The integration of images and videos (visualisation) and audio in learning units was identified as beneficial for learning outcome (details in Chapter 4).

SQu 3. How can teachers be encouraged to expand teaching practice in such a way that learning with mobile devices can support students' learning?

Both teachers and students need to become competent users of digital material. This means both should be able to select and use appropriate online-learning material. Thus, teacher-student cooperation in a workshop generates visions for new methods in-class teaching. Integrating and experimenting with supportive functionalities of mobile phones for teaching curriculum topics can trigger increased learning activities. Starting with brainstorming, drafting research strategies on paper in handwriting, thereafter getting out, taking photos or carrying out interviews, appropriate to the research topic, was very much appreciated for designing new tasks. It inspired teachers to generate similar activities for integration in other teaching-subjects, as recommended in Sammons et al (2016). Material can be adapted, and tasks suitable to the local environment can be created. The gathered material was used for creating micro-units accessible with mobile devices. Teachers perceived this strategy as very powerful for their teaching, because digital material can be reused and easily be updated.

SQu 4. How can students assist to trigger new pedagogical practice in a traditional school system in a fragile technical environment?

Youth is ambitious and generally the first group in experiencing new technologies; students in higher education in Ghana are interested in new developments; nearly all were equipped with mobile devices, mainly mobile phones. They are motivated to explore new dimensions for learning purposes. Students contribute with experience in use of various functionalities of their devices, when provided with practical support. Teachers with substantial subject knowledge and students interested in specific topics form perfect teams for co-working within interdisciplinary activities. It results in increased understanding of the topic and can improve learning outcome. Beyond increased opportunities for gathering current learning material

online whenever there is a demand, the use of mobile devices was perceived as very convenient for coping with sudden power breaks.

SQu 5. How can teacher-student collaboration stimulate new educational practice and support development of locally relevant content in a fragile technical environment?

Students were very experienced in web-search with mobile phones on actual topics; using different browsers and strategies was very common, e.g. combining keywords and content-representation. Student-teacher teams developed appropriate link lists and saved it in the cloud together with additional learning material, generated locally and integrated in micro-learning units. Learning units for access with mobile devices developed in teacher-student teams evolved over time. Structuring micro-learning units provides additional value for developing new pedagogical interventions. The units can be shared via Bluetooth on mobile devices. Comments and feedback is provided in the cloud.

SQu 6. How can mobile devices encourage STEM activities and trigger creativity in task generating?

STEM is anticipated worldwide as an important issue in knowledge generation in the 21st century (see 2.6.9). STEM approaches match with demands for employment preparation, presently widely associated with teamwork. Mobile phones support recording of experiments and tasks (photo, audio, video), which can help to better understand various facts than what is available in textbooks.

Co-working with students in addressing interdisciplinary STEM topics was experienced as a powerful strategy. Teachers are often sparsely trained for new developments not included in former curricula. Designing tasks appropriate for different curriculum topics and teamwork settings, including open-ended STEM challenge problems, are in line with the Ghanaian curriculum.

It can be assumed that the principle of self-sustainability through development of local capacity was achieved. This issue is outlined by Avgerou (2010, p.11) as an important factor for success and sustainability.

5.6 Lessons Learned

Summary of Influencing Key Factors

Critical success factors and barriers to integration of mobile learning in a developing country identified and refined during the progress of this research (Figure 5.16) are outlined in the following section.

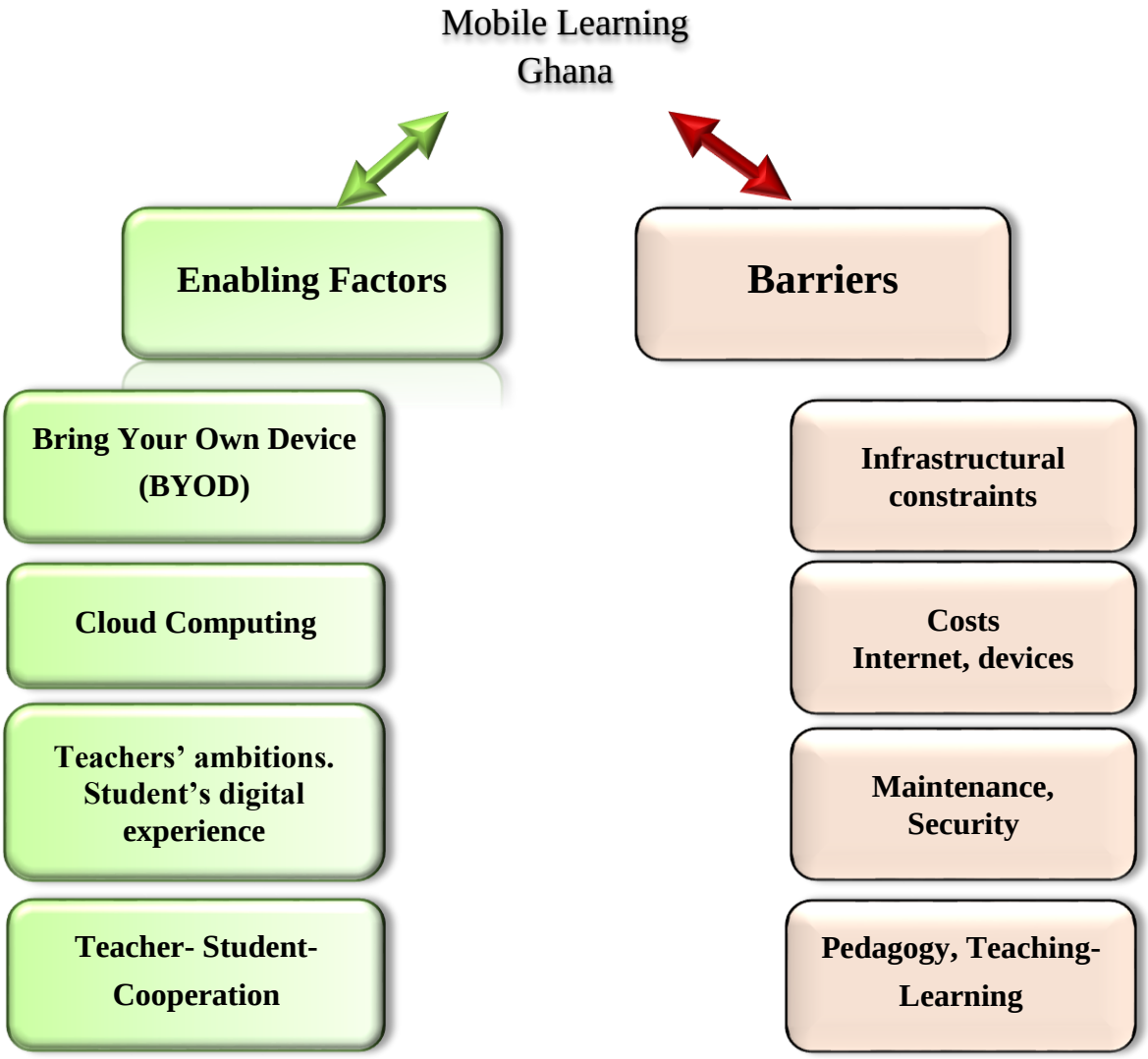


Figure 5.16 Key factors influencing integration of mobile learning in Ghana

5.6.1 Enabling factors

Organisational aspects

- Commitment of leadership (school principal and staff) was a major determinant of success; leadership plays an important role in development (see 2.4.5).
- Pre-survey for application in recruiting highly motivated staff in the first workshop was an advantage and benefited the outcome.

- Working with teachers at a pre-tertiary institution in the initial phase is preferred; they are mainly well trained in general teaching.
- The duration of each workshop (three weeks) provided time to become familiar with the equipment and for informal communication. It was beneficial for a trustful and relaxed atmosphere in breaks and on the campus, and ideal for research to gain a realistic picture of what is going on in the school over the time of the research.
- Time gap between the workshops: Teachers can independently gain experience in creating digital material and figure out new methods for teaching. Teachers cooperated with colleagues in the gap-time; this inspired others who showed interest in the developments.
- Smartphones can be shared within teams, if not everybody owns a personal device.
- Learning units can be tested on eBook-Readers and mobile phones without SIM-cards. This is in line with the prohibition of mobile phones (no mobile voice-communication was possible).
- Co-tutoring in the third workshop reflected the status of participants: The young network-specialist from Austria held close relationships with pre-tertiary students while the researcher is more comfortable with understanding teachers' interests (age- and profession-related).

Educational aspects, pedagogy

- Incorporating senior students, collaboration (teacher-student) in content development and evaluation of online material benefits the outcome.
- Teacher-student teams enforced cooperation and intensified the experience with new learning methods, launching a pedagogical shift (from instructivism to constructivism).
- Content development facilitates becoming familiar with creating scientific material, in contrast to merely passive use. When learning units are created together with teachers, academic value is added.
- Teachers have curriculum knowledge; students contribute with ideas for layout and additional information (Internet-search).
- Development of micro-content units: Learning units can be developed in the computer lab and with teachers' laptops. Small units are easier to up- and download (time-slice of connectivity, low costs for up- and download, easy to update).
- Discussions in mixed groups, including peer-feedback (also in the cloud) and presentation of material are inspiring to peers and colleagues.

- Use of mobile phones for saving content allows students to review learning material whenever they demand and have time.
- Development of personal digital portfolios can be continued independently.
- Integrating photos and videos captured with mobile phones completes learning units and presentations (visualisation, local context).
- Blogging is an easy-to-handle option for dissemination. Teachers and students posted impressions and ideas about on-going activities (www.grimus.or.at/ketascomobile, updated from time to time).
- Interview practice with mobile phones is an additional methods for widening learning opportunities (data collection, structuring).
- Transcription of interviews in pairs (listening/writing) was perceived as an additional value for English proficiency (pronunciation and verbalisation).
- Guidelines, agreements in teacher-student-teams: Responsible use of Internet (netiquette, legal and ethical aspects, copyright issues, safety and security, social behaviour) reflects interests of teachers and students, thus, is widely accepted. (Toner, 2011)
- Benefit: Wikipedia Zero in Ghana[60]: Wikipedia can be accessed without the expense of mobile data charge.

5.6.2 Barriers: Limitations, Challenges

Teachers and students in all surveys and every feedback claimed infrastructural challenges. Inconsistent connectivity (insufficient reliable electricity and scarce Internet bandwidth) are an Africa-wide problem. Maintenance costs for computer labs are a constraint to integrating ICT in the manner postulated in the Ghanaian curriculum.

Poor conditions in the computer-lab

- One computer lab for the more than 2000 students is not sufficient for integrating computers in teaching and learning, and thus does not encourage initiatives for utilisation of computers in teaching. It is very difficult for teachers without ownership of a laptop or personal computer to perform Internet research and to prepare worksheets/presentations etc.
- Poor maintenance of computers and network causes deficits in safety, security, network administration.

[60] http://mtn.com.gh/about-mtn/press/mtn-ghana-empowers-customers-with-free-access-to-wikipedia (accessed 27/2/2017) and https://meta.wikimedia.org/wiki/Wikimedia_Ghana_User_Group_/_Wikipedia_Zero_in_Ghana

Other

- Teachers' knowledge of new pedagogy and instruction modes for mobile learning is limited.
- Costs of devices and Internet service are high.

5.6.3 Coping with challenges

Mobile infrastructure and the prohibition of mobile phones discourage teachers and directly affect mobile learning interventions. Because the staff knew the administrator password (everybody could download videos etc. for private use in the background) a new network administration password was generated on a daily basis for the duration of the course, which improved connectivity.

The researcher provided a mobile connection (SIM card with 5 GB, router) to connect mobile Internet for the evaluation of OER.

In order to overcome restrictions, simple smartphones (NOKIA E5-00, Symbian operating system) without SIM cards were used for testing and experimenting. The devices are ideal for taking photos and videos; apps for various purposes were installed; uploading, sharing and testing content was possible via Bluetooth. How functions are displayed on the small screen of the device is depicted in Figure 5.17

Figure 5.17 Features installed on a NOKIA phone

Instead of using an online system (ABC) for generating ePub files, CALIBRE (software for compilation) was locally installed.

Use of cloud infrastructure (e.g. Dropbox, Google Docs) has various advantages in a mobile learning scenario. It can be used as a network resource and platform for mobile learning. According to Asabere (2013, 2011), it is more advantageous as compared to desktop computing network resources in terms of cost, flexibility and accessibility. Access to micro-learning units is possible anytime and from anywhere with mobile phones and eReaders, and can eliminate many challenges. It supports sharing material, and offers options for feedback and comments.

Groups can join a single URL, and different permissions for use can be decided. No external support is needed, particularly in Ghana, where Learning Management Systems (LMS) are widely unknown.

The technical and logistical support of a final-year student in WS 2 and WS 3 was greatly appreciated; whenever he observed someone in need he assisted unobtrusively and decent (more in the Follow up section 5.8).

5.7 Summary (Chapter 5)

Mobile learning in Higher Secondary education in Ghana addresses two specific dimensions: One focus is associated with new methods in education. This includes shifts in class teaching, access to actual information available on the web, digital skills for communication, research (evaluation of online content), best practices in the digital world (social networks, safety and security, dealing with negative aspects of the Internet, e.g. cyber bullying, fakes, etc.) and active participation in content creation.

Teachers in Ghana are forced to prepare students for national exams. There is not much space left for new interventions; however, rote learning does not match today's demands for preparing students for self-directed learning and further careers. Integration of mobile learning promotes students' abilities in developing skills to become autonomous and self-directed learners.

The other focus is based on the previous, namely to equip students with skills they need for daily and life-long learning. This is not necessarily combined with developing factual knowledge; youth need to become confident in dealing with new information and finding their position in a digital world. The ability to make use of mobile learning is an important issue for development with regard to private and employment demands.

Development of strategies for self-directed learning (life-long learning skills for the 21st century) and the availability of online learning resources are particularly important for students in higher secondary education, as outlined in Hase (2015). Access to higher education (College, University) in Ghana is still restricted in two dimensions: limitations in number for intake and affordability. Study fees are high compared to income in a developing country. Students with the ability to make use of free access to OER, MOOCs, etc. can succeed in online studies and acquire certifications.

Mobile devices are a bridge to learning opportunities. Rapid developments in technology result in decreasing costs for devices and online access as infrastructure expands in developing countries. Future mobile technology will offer increased functionalities. Individuals growing up with these technological developments need to be accustomed to making use of it for development in their countries.

Prohibition of mobile phones in schools is not only a challenge; it also impedes students becoming responsible users of mobile technology.

Best practices are only theoretically addressed (if ever) in school. In this research, mobile phones without SIM cards (for calls) were used in order to cope with the prohibition of the devices. An important issue to keep in mind is that safety issues related to online access and networks (Wi-Fi) need to be solved in advance. Nevertheless, guidelines for best practice were created with student-teacher teams, in order to provide an example for the future.

In contrast to computers, which require high financial investments and are unaffordable for governments in developing countries, BYOD is the only option to cope with requirements in education. At the time of the research, all students owned or had access to a modern mobile phone. This is an important asset, beneficial and affordable for educational purposes in school.

Cooperation of youth and teachers in their local environment could be an option for developing appropriate solutions in education and development. Culture and tradition need to be considered.

5.8 Research Follow-up: Developments from 2014 to date (spring 2017)

The study was conducted from 2012 to 2014 in a school in Keta, Ghana, supervised by a European researcher. From a distance, it is not possible to measure formal learning outcomes. However, it is important to note what was observed following the research project. Students and teachers continue with developments in mobile learning. They started with a blog on activities in 2014.[61] Students continue with creative projects and independent developments in mobile learning, peer tutoring and investigations.

Girls established the Ketasco Mobile Learning Society (MLS), after having participated in the third workshop in 2014 (see 4.6) with one agenda: to encourage the use of mobile devices in teaching and learning. With the increase in mobile technology in the country, MLS wants to educate both teachers and students on how this trend can be utilised to enhance teaching and learning. Due to the limitation of available computers, students investigate new usability's of mobile devices.

MLS continues communication with the researcher via Skype and email, discussing new developments, providing developed material in the cloud, links to videos published on YouTube[62], and reports. One year after the final workshop, six students sent reports of their on-going activities.

The group had organised various practical workshops around the town schools to foster a better teacher – student experience through the application of mobile technology. Some workshops include the use of digital media to make lessons and assignments easily accessible, others experience with android programming for smart phones and the conversion of art into a digital format.

MLS is still active at the time of writing, mentored online by the researcher and locally by Noah, a former KETASCO student. Noah had already won a price in Robotics in the Computer Creative Competition in 2013. He graduated in 2013 and assisted in two workshops. At the time of writing, he is in his second study-year on Computer Science at the College of Science and Technology in Kumasi. Noah continues with training the local community voluntarily in cooperation with other students from KETASCO. They post on-going activities in blogs and social networks, e.g. on Facebook. [63] (Figure 5.18)

Figure 5.18 Facebook account

[61] www.grimus.or.at/ketascomobile)

[62] https://www.youtube.com/channel/UCVvx_LWE871ju4Xs8N9PEkA

[63] https://www.facebook.com/kmlsociety

Students frequently cooperate and encourage teachers to participate in developments and investigations. It is important to note that girls represent quite often the majority of participants in projects. This can be observed when looking at the blogs, videos and photos.

Activities of LMS were spread out and students from other schools were invited. The group is growing, new students interested in ICT, are joining MLS. Beyond that, they cooperate with many organisations in Ghana in setting up educational events. GH SCIENTIFIC (Ghana's Premiere Science Network) published an article about MLS on their website (October 14, 2015). [64] 'Black History Month Day 14: Ketasco Mobile Learning Society'.

Some activities are organised together with visitors from overseas academic institutions. They provide feedback and are discussing new developments with the students.

The reason for talking mainly about students is that teachers are not very keen to online communication. This might be a result of cultural identity, as youth are part of the new digital generation, and the older generation is more traditional-minded, due to late Internet connectivity in Africa.

Figure 5.19 MLS invited students from other schools for STEM activities.

5.8.1 STEM Developments

The MLS group started independently in autumn 2014 with STEM projects, and is taking part in competitions.

Examples of the developments are published as photos, videos, and learning apps.

In 2015, MLS experimented with building a solar panel. (Figure 5.19)

During the KETASCO Ghana Think's Junior Camp 2014 programme [65] the group demonstrated an experiment on the use of low-cost materials in preparing oxygen, and

Figure 5.20 Preparation of oxygen gas

[64] http://ghscientific.com/black-history-month-day-14-ketasco-mobile-learning-society/ published Nov 15, 2014

[65] https://youtu.be/XrgOd82NXgI

produced the video[66] 'Oxygen Prepared Using Low-Cost Materials' with explanations (Figure 5.20) . The event was co-organised with Webster University. [67]*).*

In May 2015, MLS organised a camp. They experimented with using a drone for research on local salt-depletion (Figure 5.21).

Figure 5.21 Four photos from the salt mining project

Read below students' comments to the salt-mining project (original spelling)

'We are working on a project on salt evaporation ponds in a local community, exploring the making of the salt by using a drone. With the drone, full landscape images can be taken of the environment and fed into a computer to study the land topography; this makes it possible to study the structure of some environments to prevent certain natural disasters especially earth tremors. [68]

In November 2014, an event about career guidance and counselling was taking place at KETASCO. Students led a session on Mobile Learning, on the topic 'Comparing eBooks and

[66] https://www.youtube.com/watch?v=AmEMWdnwWo0

[67] http://gamelmag.blogspot.co.at/2014/11/capturing-second-junior-camp-ketasco.html
Blog of the KETASCO teacher who established cooperation.

[68] *http://grimus.or.at/ketascomobile/?p=346*

printed books'. The students prefer learning with eBooks on mobile devices 'instead of doing so with normal books, because they are easy accessible. Their mobile information can be found at a click.'

5.8.1 . Content Development, Programming, Dissemination

MLS continues, together with some teachers with development of learning content readable on mobile devices. The units are used as additional learning material, including up to date supplements for science and other subjects.

MLS participated in a photo competition of the eLearning Africa Conference in Addis Ababa in May 2015 and won a second prize with the contribution 'ICT reduces costs'. (Figure 5.22) Their comment (in original spelling): 'The advancement of technology over the years has made work and other activities, including education, easier and faster.

Figure 5.22 : eLearning Africa photo competition, May, 2015

For example, a Kindle-eBook reader can now be loaded with several e-books to be studied, as compared to many books bought and borrowed at high expense. This way, students are able to research a wide range of information at a click'. [69]

In November 2014 Noah and LMS started with training students from other schools in the area of Keta on a regular basis with programming a Lego Roboter (Figure 5.24).

Figure 5.23 Programming a Lego Roboter

[69] http://www.elearning-africa.com/press_media_photo_competition_winners_2015.php

Lucienne, another student, who participated in the workshop in 2014, experiences with app programming in Java. Her dream is to encourage girls in the evolution of technology and '*build a multi-million IT company'*. One of her apps is intended to help her colleagues with calculations: Velocity, Acceleration, Distance and Speed at a click! (Figure 5.23)

Figure 5.24 Lucienne's presents her Motion Calculator

Figure 5.25 Destiny, working on animation effects in 2016.

Her comment: (original spelling)

'I command my device by voice for it to respond and work on it to give me expected results. Again i use it to study online if i feel too tire to sit and code on computer. I used it to try web application that i have been developing to see the responsive effect.' (28. July 2016) [70]

She was invited from a Ghanaian broadcast station for an interview about her experiences and received much appreciation in the postings. (Download app from https://goo.gl/EIbpKO)

[70] http://grimus.or.at/ketascomobile/?p=413 and https://www.facebook.com/kmlsociety/photos/pcb.1792019681034977/1792004214369857/?type=3 .

Destiny, a 15 years old member of MLS experiments with animations. [71] (Figure 5.25) He demonstrates some of the short animations he had programmed. The video is available from https://youtu.be/gQudw3YtNEM).

More examples can be found in the MLS blog[72]

5.8.2 Material, available online

Seven educational videos on basic computer skills developed in workshop from MLS (August to September 2016), were uploaded from Noah, .on the topics

- Creating an email account with Gmail [73]
- Signing In: Gmail account [74]
- Signing out: Gmail account [75]
- How to compose an e-mail [76]
- How to read e-mails [77]
- Print Screen and Paint [78]
- Snipping Tool [79]

5.9 Researcher's Personal Summary

From the on-going activities in STEM and developing material for use with mobile devices, it can be assumed that the study was successful. It is necessary to cooperate with teachers and students in a way that allows both groups to experience how technology, available to them, can be used for new approaches in different disciplines. To find out together what is useful for the learners (teachers as well as students) is an important issue. Only when they are experiencing new practices useful in their environment and generate ideas for further developments, it can be said that the outcome of the research will be flourishing on the long run. Students learned to use devices as tools for knowledge creation and teachers learned that cooperation in teams with students contribute to generating new methods for learning support. Working together is important for developing new models for education; to be prepared for 21st century demands needs to develop competences for self-guided learning.

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[71] https://www.youtube.com/watch?v=gQudw3YtNEM&feature=youtu.be, Video uploaded February 19, 2016

[72] http://grimus.or.at/ketascomobile/?p=300

[73] https://www.youtube.com/watch?v=RwQdSfshodo&list=PLi_jtrxnw3ThI7FW457Ro0t1_jSQV5ANE&index=3

[74] https://youtu.be/dltTXQuPxJY?list=PLi_jtrxnw3ThI7FW457Ro0t1_jSQV5ANE

[75] https://www.youtube.com/watch?v=dltTXQuPxJY&list=PLi_jtrxnw3ThI7FW457Ro0t1_jSQV5ANE&index=4

[76] https://youtu.be/LqS6-jgmjOs?list=PLi_jtrxnw3ThI7FW457Ro0t1_jSQV5ANE

[77] https://www.youtube.com/watch?v=HYr8Hv5nxFc

[78] https://youtu.be/kvSUAPFaPlU?list=PLi_jtrxnw3ThI7FW457Ro0t1_jSQV5ANE

[79] https://www.youtube.com/watch?v=1IJvX03WVE4

Providing realistic, relevant learning experiences and allowing ample time for practice and feedback, together with taking the advantage of cooperative methods in working together with two generations was experienced as an avenue for reducing the digital divide. Building up basic skills and allow students and motivated teachers to come up with own ideas for developments appropriate to the environment and needs is a perfect model for future evolution.

6. Conclusion, Recommendations

6.1 Introduction

This chapter presents a brief outline of the research problem articulated in Chapter 1, in combination with considerations for practical attempts to stimulate mobile learning in developing countries in Africa, based on the research outcome.

The research was conducted with focus on

- the current status of ICT and education in sub-Saharan Africa, and
- Opportunities and challenges for integration of mobile devices (mainly mobile phones) in teaching and learning in Ghana.

The broad aim of this study was to explore how mobile devices can enhance learning and widen recognition of non-traditional learning in a developing country in sub-Saharan Africa. The research was contextualised in the field of mobile learning with a specific focus on new teaching approaches by reflecting educational strategies found in the literature (see section 2.7). The research was conducted at a Senior Technical High School in Ghana.

Three intended outcomes were addressed:

- Developing understanding of how changes in teaching can be stimulated to trigger advances in learning opportunities.
- Understanding how mobile learning and access to online material can be integrated in daily practice.
- Understanding how students can be integrated to assist in developments.

The overall goal is to empower teachers to disseminate their experience for adoption in other schools.

Based on the literature review conducted in Chapter 2, results from multiple data sources are analysed and interpreted in Chapters 4 and 5.

6.2 Research Problem Revisited: Key Issues

Because investments in the resources (rooms, furniture, hardware, teacher education, on-going support and service) required to optimally implementing ICT in education are not affordable in most developing countries, other options for improving the quality of teaching and increasing learning opportunities are an important issue in educational research. (Majgaard & Mingrat, 2012) Fundamental issues to take into consideration are infrastructure, education and ICT (including educational policies and teacher professional development), and young people, their openness to new developments in the local environment, with regard to culture, tradition and ethics.

6.2.1 Infrastructure

Ghana, like other developing countries, faces challenges due to poor infrastructure (electricity, frequent power cuts), inadequate Internet connectivity (low bandwidth, high costs), scarce access to ICT (computers and peripherals in overcrowded or often locked computer labs, high student to computer ratio), lack of equipment maintenance and technical support (installation, troubleshooting), and sometimes vandalism.(Basak & Govender, 2015; Oyerinde, 2014) This is a reason that the promised advantages of ICT policies in education could not be achieved as decided.

6.2.2 Education and ICT

Aside from the above-mentioned impediments, pedagogical tradition also hinders the use of ICT in education in Africa. Educational systems face a shortage of qualified and motivated teachers capable of delivering quality teaching within a 21st century educational context. Besides the scarce availability of ICT infrastructure in schools, teachers often lack the knowledge and skills to use the equipment in computer labs for delivering subject-relevant content in an effective and learner-engaging mode.

6.2.3 Young people

Most students in higher secondary education own or have access to mobile devices, mainly modern mobile phones. This is an advantage and can shift the aim of educational policies from ‘education for ICT’ to the use of mobile devices for learning purposes, by integrating practicable objectives for mobile learning throughout the curriculum. Mobile devices can complement traditional learning material formats and thus expand appropriate learning experiences for individual students.

6.3 Reflection on the Research

Educational research cannot be reliable if it is disconnected from the complexities and challenges of local practice. Well-intentioned projects are often designed and developed outside of the context in which they are actually used, and therefore fail in the long run. Some important aspects figured out as relevant for success are as follows:

6.3.1 Scope of the literature review

An extensive literature study helped in developing a deeper understanding of the complexity of interrelated issues in a developing country. It guided suggestions for designing the research framework and illuminates findings.

6.3.2 Selecting the region and school

A Senior Technical School in the South of Ghana was identified as an ideal setting for the research (see section 4.3). The official language in Ghana is English. This provides a general benefit for the study in two ways: It can enhance digital literacy and language skills when

accessing material from the Internet; further research can also easily be shared, as English is a common language in research.

6.3.3 Participants

The goal of this research was not restricted to tutoring teachers in use of digital devices; the overarching goal was to encourage teachers and students to continue with further developments independently, particularly in cooperation with teacher-colleagues and peer-students from different grades.

The intervention phase of the first cycle was a teacher workshop in the 2012 summer vacation period. This was continued with workshops in the following two action research cycles (2013 and 2014), incorporating students in the workshops as well. The collaborative partnership between the researcher, local teachers and students was experienced as a successful strategy, as outlined by Cochrane (2011): 'a participatory approach benefits the adoption of new teaching and learning attempts'.

6.3.4 Pedagogy

Hands-on workshops and promotion of collaborative learning opportunities encouraged teachers and students to explore the potential of digital tools and resources available in the school together with their own devices. Tasks related to STEM activities were generated; learning units were developed and adapted for access using mobile phones and eReaders.

The intervention phases in the research cycles were pedagogically rather than technically focused; they aimed to develop awareness of the potential of mobile devices for learning purposes. A participatory approach, as outlined above, was very important in developing mobile learning interventions meeting the needs of teachers and students: both have diverse knowledge levels and interest in a specific topic.

Development of learner-generated content has a beneficial impact on information discovery and defining tasks for the design of new learning approaches. Skills for information gathering and evaluation of online learning material were identified as a basis for formal and informal learning. This supports rethinking pedagogical interventions and knowledge building approaches. Feedback from a teacher (gathered in a third-cycle survey) outlined the aspect of considering students' needs by asking them for feedback about their perceptions of newly designed tasks and assessments. He stated that this could add value in further developments with use of mobile devices and increase teachers' engagement in designing new tasks. Many apps for mobile phones are freely available, and mobile phone functionalities will become even more prevalent in the future.

There is potential in higher education for creating or adapting digital open educational content for local demands and curricula. Such activities can stimulate new pedagogical attempts, based

on constructivist, contextual, and collaborative principles in teaching and learning, as a user-centred approach, engaging teachers and students in a responsive and comprehensive way.

Another issue is related to the devices themselves: the small screens of mobile phones are not ideal for certain types of content, e.g. large text or illustrated eBooks. Content creation needs to take into consideration bandwidth and limitations of formats.

6.3.5 Guidelines – use of mobile devices in school

Prohibition of mobile devices (smartphones) in higher education is counterproductive. On the other hand, acceptance of mobile devices for integration into learning activities poses significant challenges for teachers and school authorities. While modern mobile devices are particularly well suited to support learning, ethical and behavioural issues must be considered as an essential impact for education. Although using mobile phones in class can simultaneously disrupt educational practice. Development of regulations for educational use contributes to openness towards using mobile devices as a tool to support and enhance learning opportunities. Cooperative development of recommendations and guidelines for improving the situation in schools also aid in crossing boundaries between formal and informal learning.

6.4 Tracking on-going Activities

Online communication in the periods between workshops informed the researcher of further activities and aided in keeping track on developments on-site. The researcher assisted with thematic support; discussions were conducted online. Thus, mobile devices are a popular tool and allow basic observations even from outside the continent.

6.5 Condensed Answers to Major Research Questions

Qu1: What are most important issues to consider when planning the integration of mobile technologies in learning and teaching in a developing country in sub-Saharan Africa?

School policy

Personally owned digital hand-held devices (BYOD-strategy, see 2.9.3) can be a supplement or an alternative to resources provided in schools. Students can share devices when working in groups. Guidelines for responsible use of the devices should be developed through teacher-student cooperation, which increases acceptance.

Schedule for training

Workshops should be scheduled at times without competing duties, followed by a sufficient period for teachers to try out new tasks and methods, building upon their newly gained skills in

daily practice, and sharing experience with colleagues, before continuing with follow up training.

Infrastructure

Free Wi-Fi should be provided, and safety and security in network management must be rigorously assured. Access to computers and/or laptops for content development should be available in a computer lab.

Qu2: How can mobile learning be initiated as a beneficial supplement to education in a Senior High School in Ghana?

Teacher-Training

According to the literature, there is limited empirical information about access and use of ICT tools among secondary school teachers and their competencies in Ghana. (Sarfo et al, 2016) Integrating mobile devices into teaching and learning can shift pedagogical approaches from traditional instructive learning theories to contemporary needs for lifelong learning attitudes.

Teachers need basic skills in using ICT for developing material (worksheets, presentations) to support teaching practice in the initial phase. It is important to start with highly motivated teachers. Voluntary participation in free time is thus beneficial and let them time to increase proficiency gradually. After developing basic digital literacy teachers experience how digital material (micro-learning modules) can be developed on computers and laptops in a follow-up workshop after a period of experimenting in teaching reality.

Upper-grade students can be integrated after teachers have gained basic digital literacy skills. The multi-functionality of mobile devices is best experienced in teacher-student teams. Participants learn how to use mobile devices as a beneficial supplement in teaching and learning. Mobile devices for accessing learning material are also an advantage in coping with power cuts.

Pedagogy

Presenting and discussing individually developed material contributes to becoming familiar with a constructive learning paradigm. Feedback needs to be provided continuously. Teacher-student collaboration in the workshop stimulates new educational practice in a traditional school system with a fragile technical environment. Students are often digitally perceptive and can assist in content development, search procedures, layout and design of material for topics selected by teachers. This stimulates more sophisticated task design and STEM activities, and triggers suggestions for new strategies and formats for tasks.

Teamwork benefits both, teachers in understanding students' specific demands for up-to-date factual knowledge, and students in developing skills for life-long learning strategies, especially

when considering rapid technological developments, which demand permanent adoption of learning strategies.

6.6 Practical Value of the Research

The research provides a realistic understanding of how mobile devices can best be used to supplement local ICT resources to improve learning opportunities together with a shift in pedagogy in a formal educational setting. It is demonstrated that student-teacher and student-student collaboration is essential for a shift in pedagogy and affects outcomes. Students and teachers experienced a variety of strategies while actively involved in various tasks.

The potential of mobile phones (smartphones) connected to the Internet offers great opportunities for teaching and learning for both parts. Understanding these opportunities is of value for the careers not only of students, but also of teachers. As outlined in Chapter 4, the efforts in this project yielded positive changes in learning and pedagogical practice.

The methodology and design of this study (Chapter 3) can narrow the knowledge gap in the literature on integration of learning with mobile devices in higher secondary education in Ghana and can be beneficial for planning similar interventions in sub-Saharan African countries.

Research and practice were grounded and considered by taking into account local tradition and practice. The principle of self-sustainability through development of local capacity, as outlined by Henessey (et al, 2010) was clearly addressed.

Although the study faces limitations (see 6.9), this research contributes to the body of knowledge on two levels:

- Shift in pedagogy and teaching methods, and
- Students' use of mobile devices for knowledge development.

The research has validated the idea that when teachers and students are actively engaged in the development of new learning approaches, the outcome is better than when curricular changes are imposed from outside with formal policies. (Unwin 2015, p. 14)

As technology develops and prices come down, tablets and eBook Readers will complement the use of mobile phones for learning purposes. Free access to quality online educational content opens the road to the decline of the knowledge gap between students in developing countries such as Ghana and those in the developed world. However, this will only be a success if the rise of a second digital divide, related to digital skills and combined with new learning strategies, can be minimised.

6.7 Suggestions for Future Research

Use of mobile technology for learning and teaching is still an emergent area. Mobile learning widens learning opportunities not only in formal education; it is often referred to as an

appropriate avenue for social and economic development. Interventions need to be grounded in local context and culturally embedded so that lessons are learned and knowledge is accumulated.

Studies need to recognise the influence of cultural and social characteristics of the region. When planning an intervention it is necessary to consider the particular teaching and learning needs and the technologies that are available.

Teachers' proficiency and knowledge of the potential of mobile devices for supporting teaching and learning is fundamental. For sustainable integration of mobile learning, it is necessary to have at least digitally literate and confident teachers.

Mobile devices allow teachers to experiment with new teaching methods; young people in Ghana want to experience new functionalities with their own digital tools. Sustainable changes usually come through individual developments and decisions rather than through regulations and policies from the government.

When teachers gain new pedagogical insights into the potential of the tools, it helps them to integrate new tasks in accordance with the curriculum. User-owned devices (BYOD, see section 2.9.5) are cost effective with regard to low maintenance costs and replacement of out-dated technology. Beyond this, sharing a handheld device is a common tradition in many African countries.

Teachers in higher education can draw on the digital proficiency of upper-grade students, and use online tools as a powerful force to suggest and incorporate online resources in their daily routine. Students can assist in the development of small digital learning units. Students taking learning more and more into their own hands, for example, developing relevant content for peers, is beneficial for teachers as well.

Areas for further study should include inquiries into measuring effects of mobile learning outcomes in developing countries as an important issue. More research is needed to understand what works, how, and why, in both formal and informal environments.

6.8 Factors contributing to successful interventions, Recommendations

Before starting a research the selection of an appropriate school and incorporating highly motivated teachers, participating voluntarily in the workshops, is important.

Gathering information about a computer lab prior to an intervention in a school should address availability of stable electrical power or a generator; stable Internet connection or mobile Internet (including maintenance and network security, and whether coverage of connection costs is guaranteed by the school), and availability of Wi-Fi (whether only in the lab or campus-wide free access for students).

Accessing the web with a mobile phone is referred to in the literature as a user's first Internet experience in Africa, mentioned as a Post-PC experience. For this reason, low-cost portable technologies (mobile phones or low-power handheld devices) can be regarded as a supplement or eventually a substitution of a single computer lab in schools with overcrowded classrooms.

Storage and sharing content in the cloud can compensate ideally for infrastructural challenges.

The duration of the workshops should provide enough time for figuring out local demands, discussions, feedback, and developing new tasks appropriate for local practice. At least a couple of month between the workshops enables teachers to experiment with newly gained skills in daily practice.

Cooperation of teachers and students in teams increases knowledge creation and creativity in designing tasks for mobile learning activities. Highly motivated students can disseminate skills and continue experimenting with new ideas for task generation and use of sophisticated new features of devices. In this research, it was observed that students continued with involving teachers in mobile learning activities outside of formal school lessons, and in tutoring and assisting in maintenance of resources. New teaching and learning methods are thus experienced informally.

Development of practicable guidelines for responsible use of mobile devices supports the acceptance of regulations. All together, these factors can establish a sustainable basis for independent further developments.

6.9 Limitations

The study was limited to a Senior Technical School in Ghana, representing a specific educational context. The project was designed on small scale, without external funds, based on the environment and specific needs of the school in Keta. Although some factors and influences are not measurable, it can be argued that e findings are relevant for future research in a similar environment.

6.10 Brief Summary

The research aimed to find a solution for better learning conditions in a developing country by investigating how mobile devices can be integrated in learning and teaching processes in higher secondary education to supplement scarce resources with up-to-date study material and updated pedagogy. Integration of mobile devices in teaching practice can potentially enhance students' interest in new learning opportunities and help them to be prepared for lifelong learning. Mobile phones are now nearly universal and provide access to content and learning where other options are limited. However, mobile devices will not solve development problems by themselves; skills to make beneficial use of these tools are basic requirements for development.

Mobile learning represents a significant change from traditional education practices. It can be integrated in education as a complementary learning offer, however it demands rethinking of pedagogical practice. It is important that teachers experience how mobile devices and tools can enhance students' learning activities and to consider how this can help students to meet learning demands. Extending learning beyond the classroom with practical implications and use of mobile devices is beneficial for promoting new teaching and learning methods, and coping with the growing complexities of formal and informal learning. (Cox, 2013)

This study has a strong focus on practicability in the field. Mobile devices have been used as tools for new learning opportunities. Ideas for using mobile technologies in teaching and learning were integrated in tasks based on the local curriculum. The use of mobile devices in transformative ways, such as participatory and collaborative approaches, was encouraging teachers and students to experiment on topics and with tools relevant to develop 21st century skills. Teachers and students are encouraged to integrate mobile devices and online recourses into daily learning.

The findings could assist educators and school authorities in planning similar interventions of integration of mobile learning in higher education in developing countries. The framework of the research might be helpful for moving from this pilot to a mainstreaming approach and for similar interventions in other schools in Ghana.

Figure 6.1 Students are excited about the outcome, June 2014

Developments during the research were published in peer-reviewed journals and presented at international conferences (Appendix 0, publications related to research cycles).

In May of 2015, the study was presented in the eLearning Africa conference in Addis Ababa. In discussions with experts from sub-Saharan Africa and other developing countries, it was found that there is increasing interest in this type of research.

The author looks forward that mobile learning practices experienced during the workshops will inspire other teachers and students to integrate mobile technologies in their daily learning routine.

. ***'Mobile phones are now the laptops of Africa'.*** (Vänskä, 2013, p. 14)

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Final link-check in April 2017 (if not separately noted)

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